Major Changes in International GrainTrade to 2025 & Beyond!

Implications for Transport Infrastructure Planning

to the ACE NETS Modeling Symposium
June 21-22, 2004
Alexandria, Virginia

William W. Wilson in Collaboration with:
E. DeVuyst, W. Koo, Skip Taylor and Bruce Dahl
North Dakota State Univ

Motivations

- Outlook, longer term, for world grain flows
- Impacts on Upper Miss. grain flows, w/wo expansion
  - --to 2050
- Impacts of consumption, intermarket, intercountry and intercommodity competition
- Impact of uncertainty/risk over time
  - Uncertainty has very important impact on project valuation and management
  - How far forward are forcasts relevant/valid
  -

National Academy of Sciences,

- *Review of the U.S. Army Corp of Engineers Upper Mississippi-Illinois Waterway Restructure Feasibility Study: Interim Report* (2004).
- p. 15 "...to develop a model to include the impacts of the amount grain grown in the upper Midwest, grain production in competing country ("especially Argentina and Brazil") and demand for grains which is a function of population, income, etc. In addition, it accounts for competition amongst competing transport modes and their prices.

Presentation

- Previous studies
- NA and World Grain Trade
- Comparative production costs
- Forcasts for Import Demands
- 3 Fundamental Factors--details
  - Ethanol
  - Brazil
  - China
- Panama Analysis
  - Model
  - Results
  - Lessons/learned
- ACE I Model: Spatial competition and Barge Flows/Projections
- ACE II Model: Stochastic optimization of Spatial Flows and Projections
- Preliminary review of data/issues
- Discussion

Previous Studies -- Large Scale Transport Infrastructure Projects

- Types of studies
  - Barge costing models (Towcost -ACE)
  - Flow Forecast Models using past history
  - Essence (ACE)
  - Delphi (Sparks)
  - Non-Spatial Gross Trade
  - Spatial Equilibrium

Previous Studies -- Large Scale Transport Infrastructure Projects

- Projections (Export, barge traffic)
  - Based on past history
    - May assume constant proportion of trade flows
  - Framework
    - USDA-ERS
    - FAPRI
  - Each tend to over-estimate exports

Previous Studies -- Large Scale Transport Infrastructure Projects

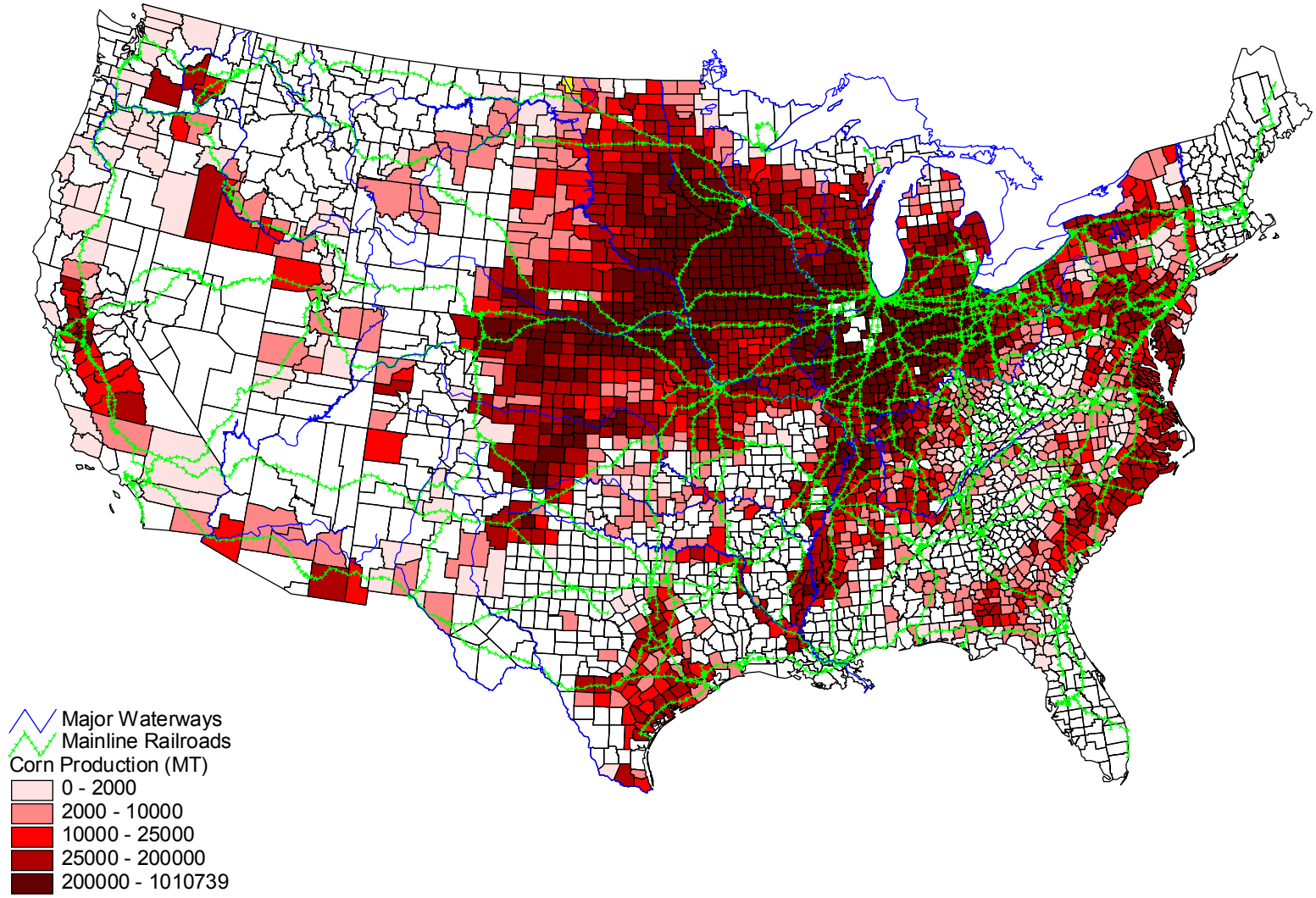
- Risk--rarely considred
  - If considered,
    - generally implemented by alternative scenarios, with optimistic and pessimistic forecasts
    - Sensitivities
    - {as opposed to quantifying risk}

Previous Studies -- Large Scale Transport Infrastructure Projects

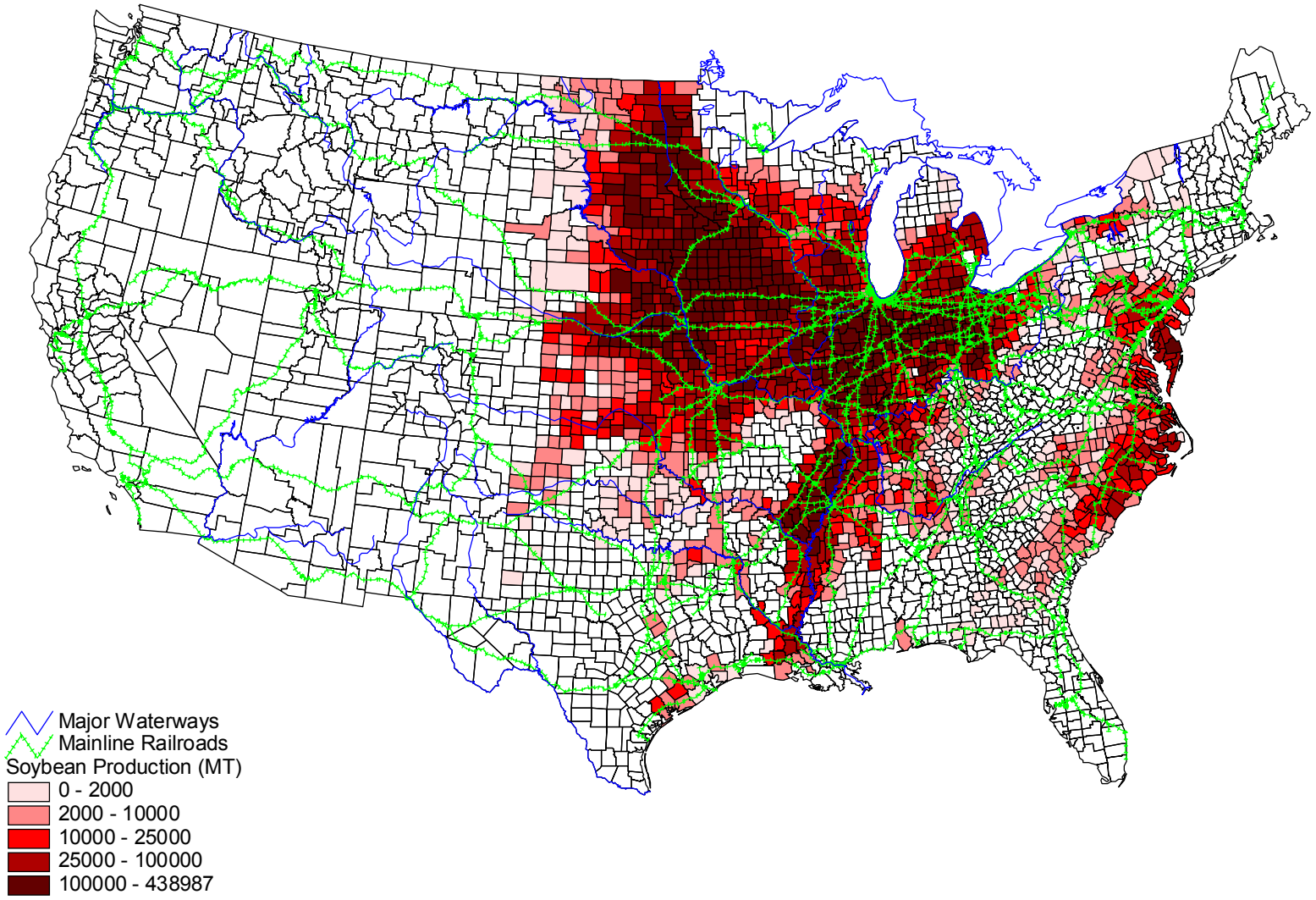
- Critiques
  - Sweeney
    - Model must consider alternate mode/route substitution when estimating effects of increased costs on barge traffic
  - Baumel et al.
    - Past forecasts (USDA-ERS, FAPRI) for exports are optimistic when compared to actual.
    - Models based on policy simulations, ignore spatial competition and transportation, impacts, can't account for exogenous changes

US and World Grain Overview

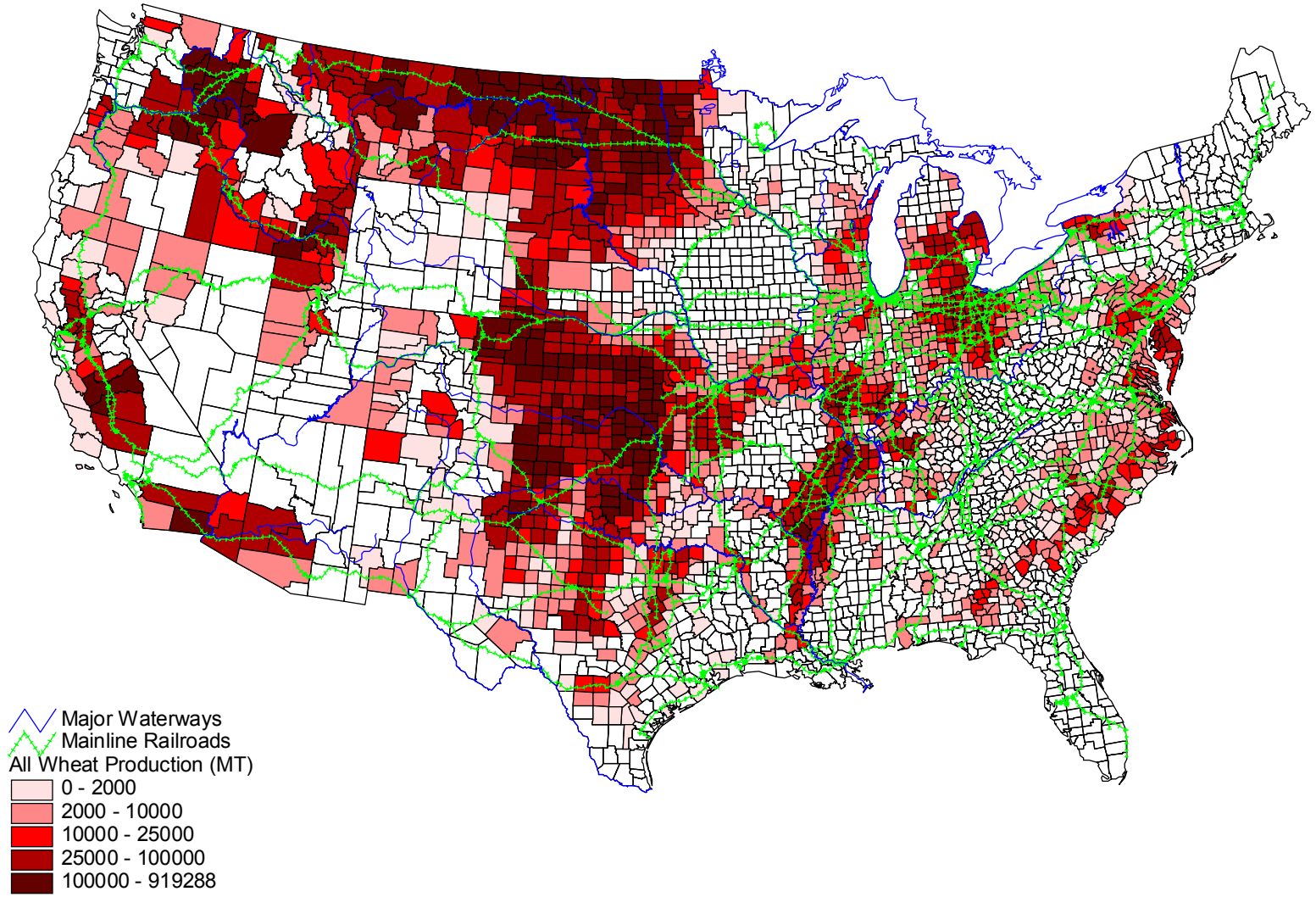
Corn Production, 2001



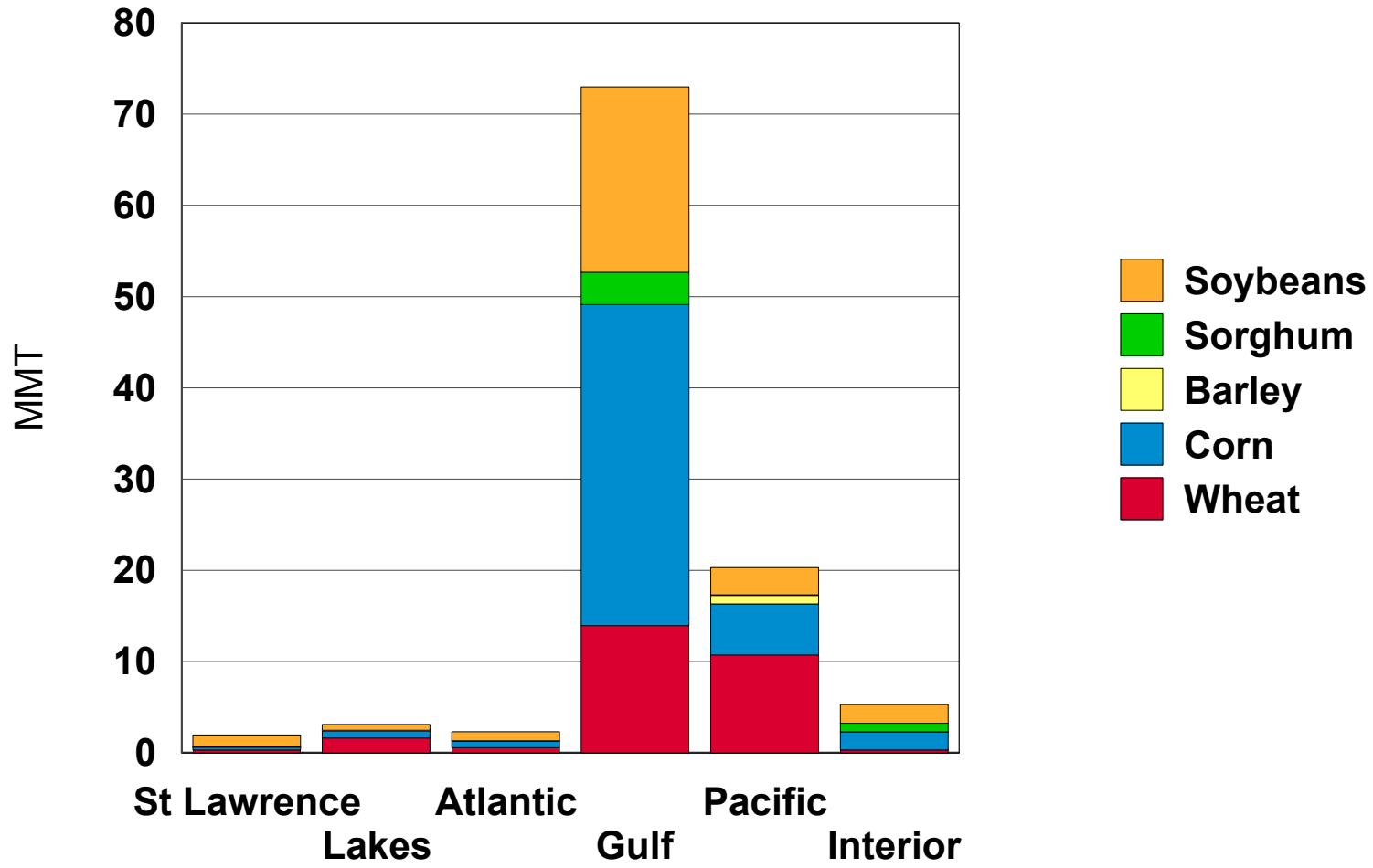
Soybean Production, 2001



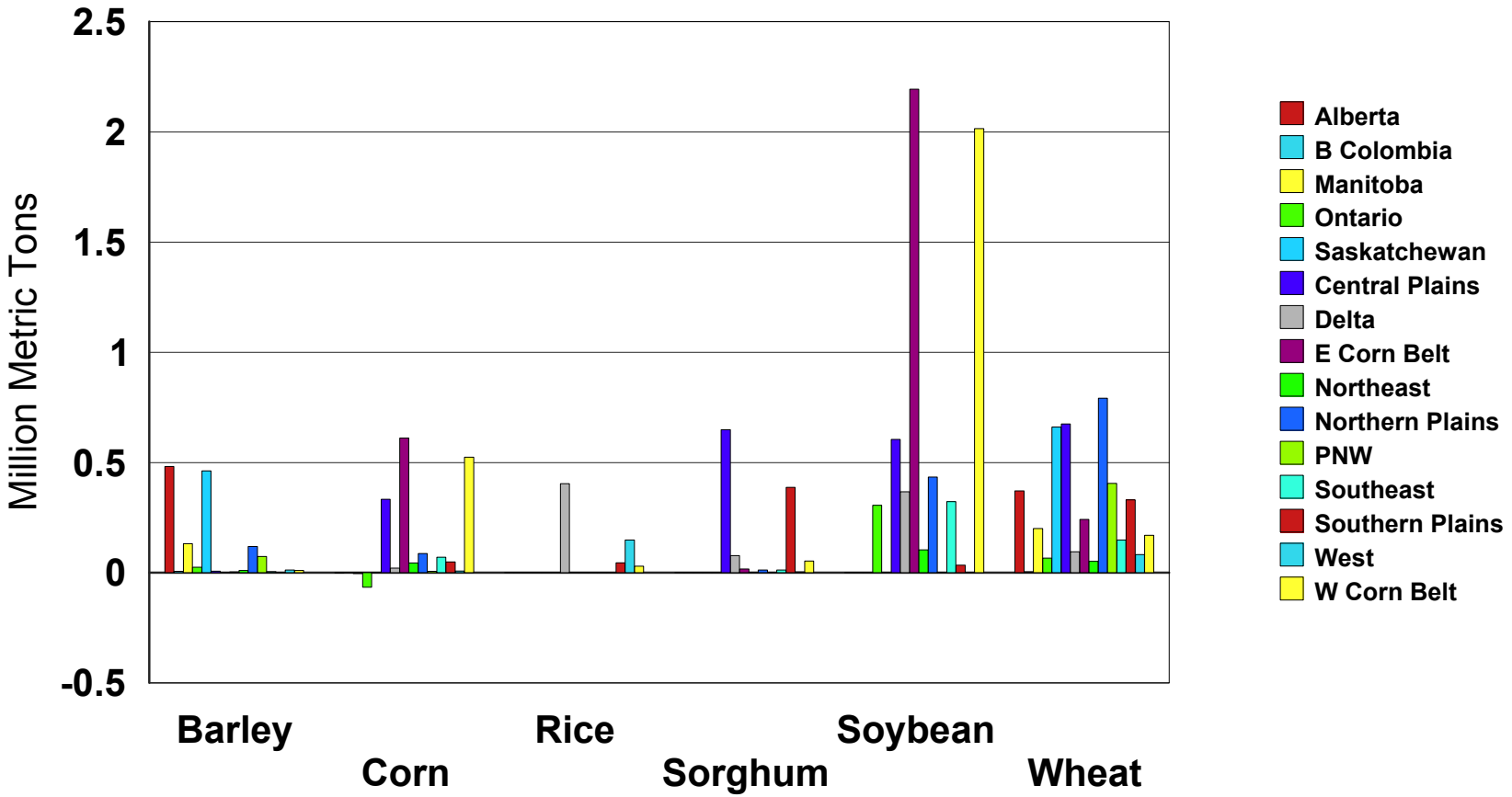
Wheat Production, 2001



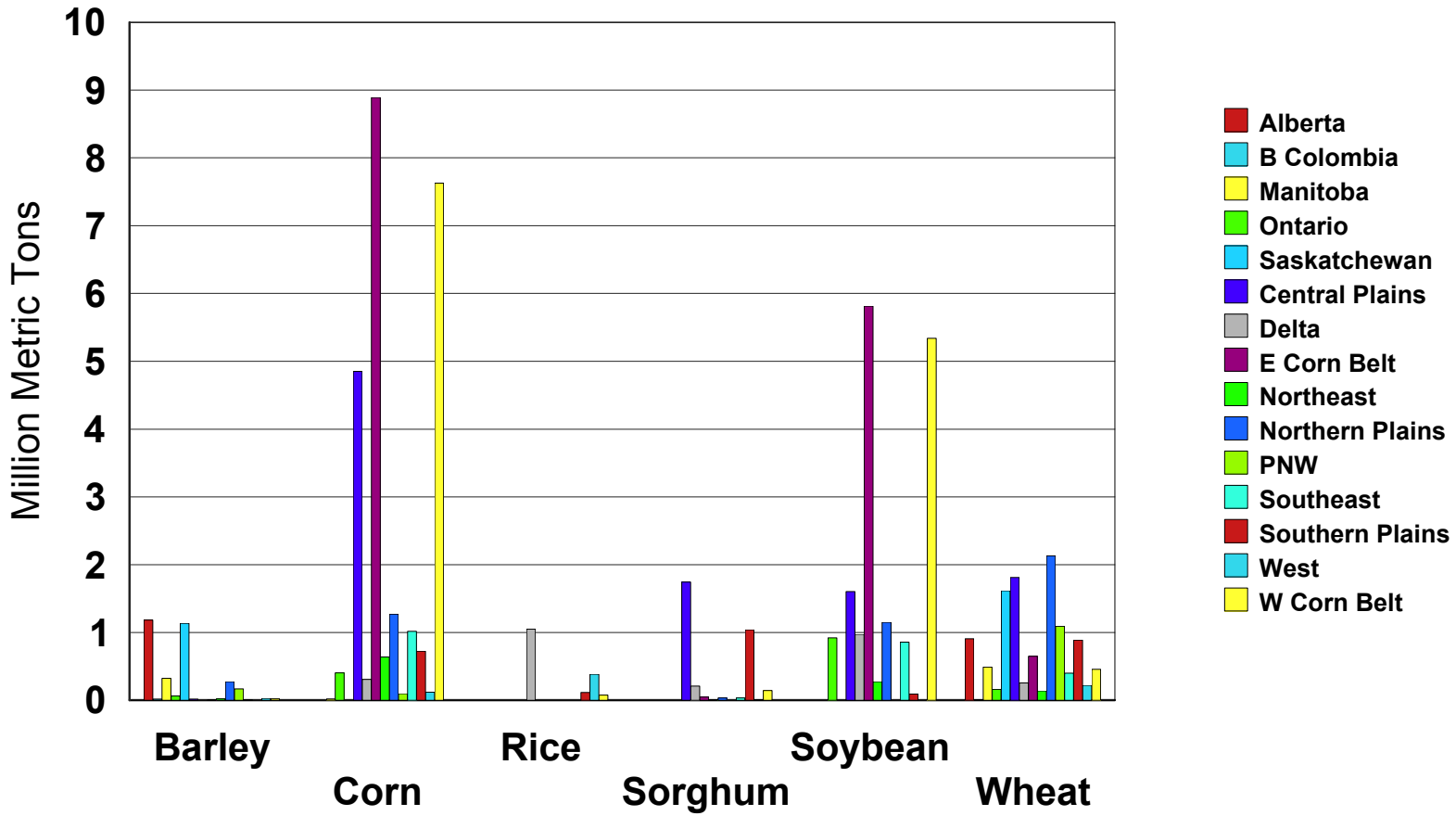
Exports for Port Areas, by Grain



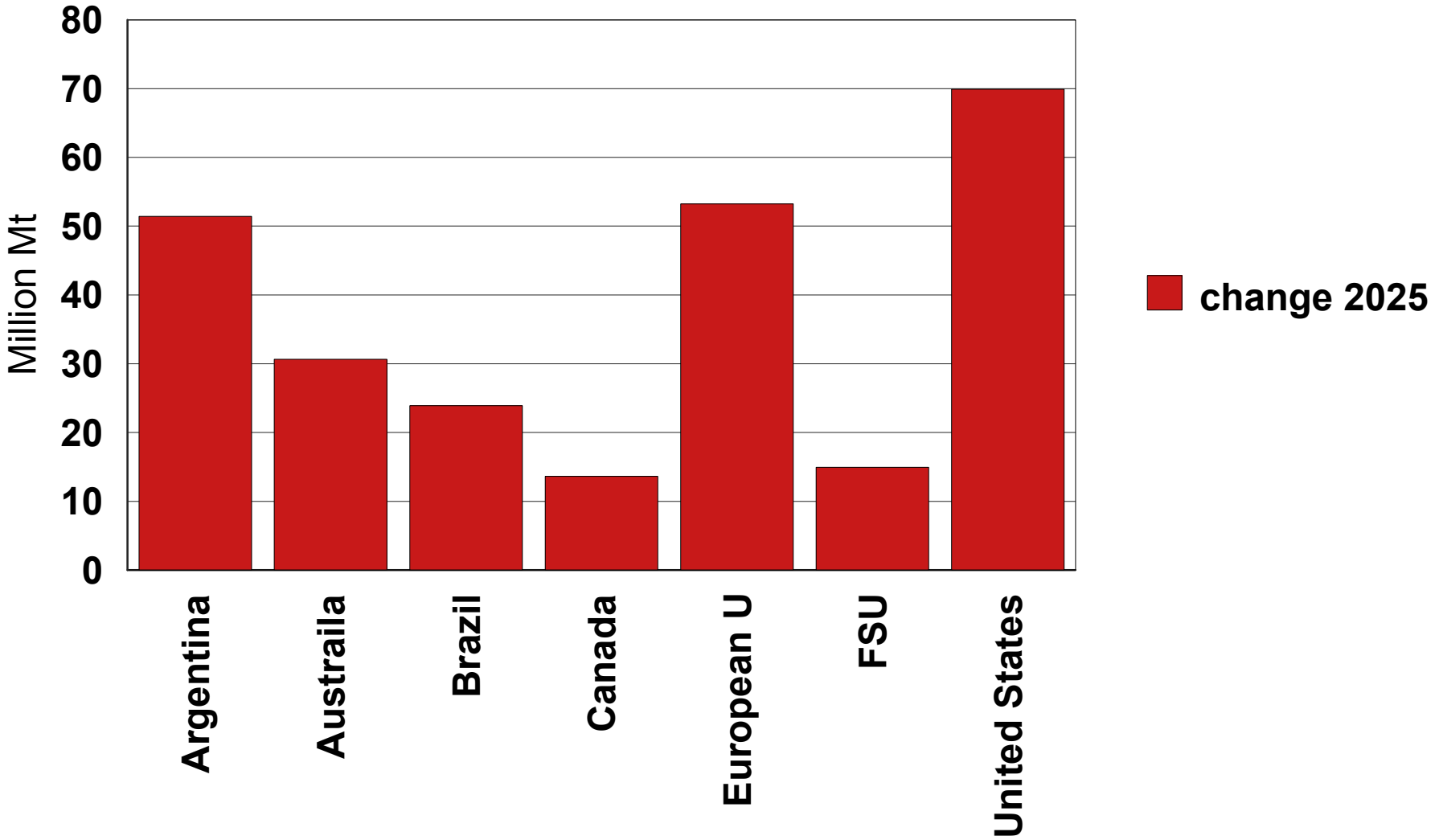
North American Change in Production 2010-2002, by Region and Crop



North American Change in Production 2025-2002, by Region and Crop



Potential Increases in Export Supply



Comparative Production Costs

- WEFA--2000 to 2015
- US Production regions
- Comparative international market

Cost of Production, by Crop ($/HA)

	Barley	Corn	Rice	Sorghum	Soybean	Wheat
Argentina	- -	449.4	- -	287.97	209.46	200.67
Australia	169.74	- -	- -	- -	- -	164.83
Brazil - South	- -	290.51	- -	- -	283.79	267.62
Brazil - North	- -	290.51	- -	- -	283.79	267.62
Can. - Alberta	267.52	581.74	- -	- -	- -	242.38
Can. - B. Colombia	267.52	581.74	- -	- -	- -	242.38
Can. - Manitoba	267.52	581.74	- -	- -	- -	242.38
Can. - Ontario	267.52	581.74	- -	- -	323.39	242.38
Can. - Sask.	267.52	581.74	- -	- -	- -	242.38
China	- -	801.85	940.51	607.34	504.12	767.25
European Union	- -	487.23	- -	- -	396.15	453.96
FSU	- -	- -	- -	- -	- -	- -
India	- -	72.98	168.83	73.74	- -	158.91
Thailand	- -	229.26	232.73	76.68	157.8	- -
US Central Plains	218.49	507.17	- -	220.65	200.69	133.17
US Delta	218.49	437.86	941.27	266.9	234.34	133.17
US Eastern C. Belt	218.49	432.12	- -	220.65	200.69	191.83
US Northeast	218.49	411.52	- -	220.65	200.69	191.83
US Northern Plains	218.49	507.17	- -	220.65	188.12	135.19
US PNW	218.49	- -	- -	- -	- -	327.35
US Southeast	218.49	437.86	802.12	266.9	256.47	280.61
US Southern Plains	218.49	507.17	817.61	266.9	188.12	133.17
US West	218.49	- -	1308.67	266.9	- -	133.17
US Western C. Belt	218.49	432.12	817.61	220.65	200.69	191.83
Vietnam	- -	68.43	111.06	- -	- -	- -

Comments/Discussion

- Cost differences are critical in determing *Long-run Competitive Equilibrium*
- Revised WEFA estimates provide greater detail on
  - Revised USDA regions (do not follow state lines)
  - Regional differences in Brazil
  - Detail on EE and FSU

World Grain Trade

- Matrix---current scope/volumes of world grain trade

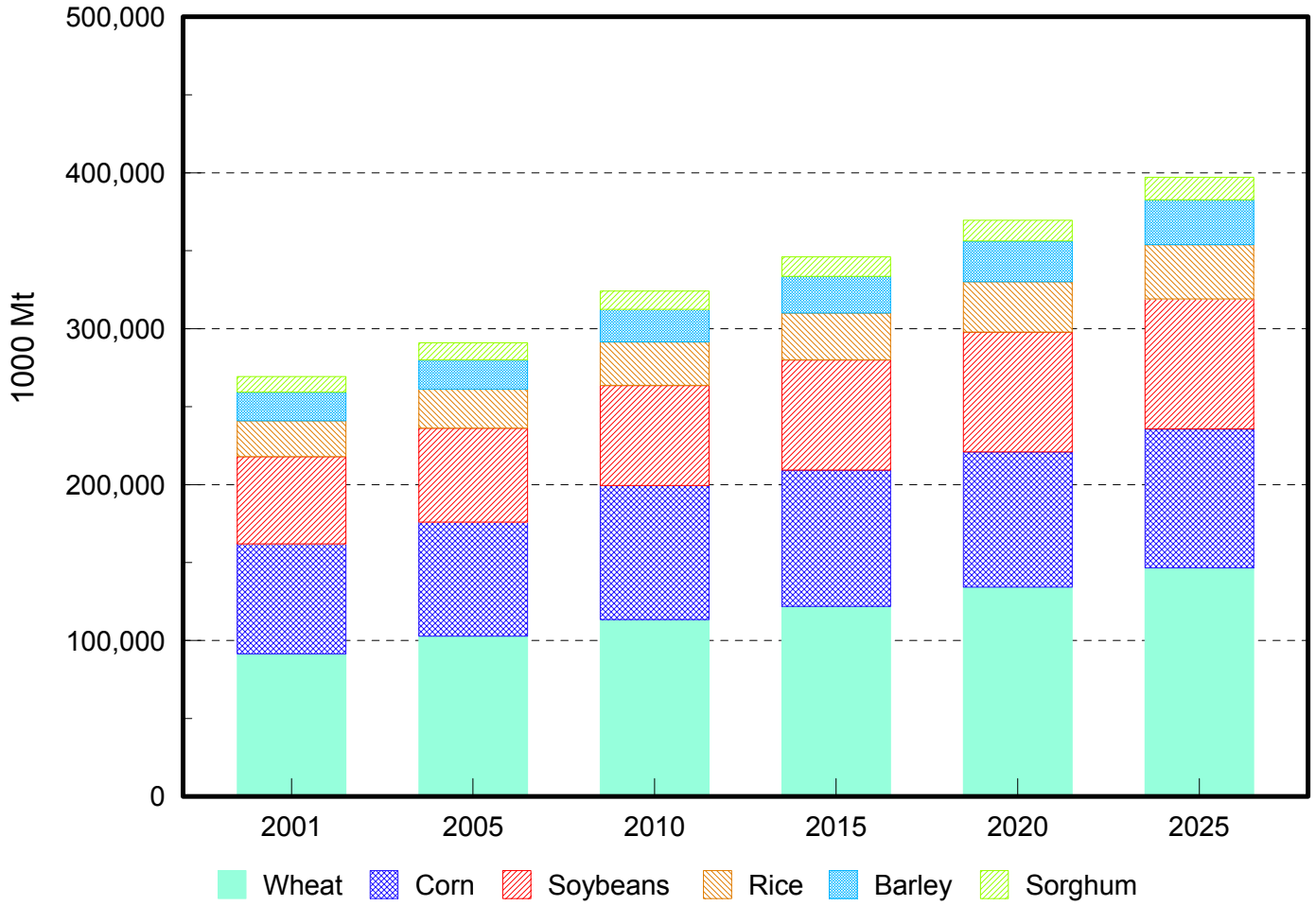
Grain Trade Matrix (Total in 000mt)

	US			*Canada*		*Brazil*	*Argentina*	***Total***
	East C.	West C.	Gulf	E. Coast	W Coast			***Trade***
Importing Country/Region								
E. Europ	0	0	68	22	0	75	10	175
Western Europe ((EU)	3,370	5	6,172	1,093	48	7,271	2,918	20,878
FSU	7	84	1,841	4	0	2	85	2,023
East Asia	1,176	15,860	27,695	407	3,132	1,051	1,871	51,193
China/Hong Kong	347	1,265	4,825	335	1,057	621	1,040	9,489
Japan	747	8,202	15,189	72	1,941	364	682	27,197
S. Korea	82	3,487	3,387	0	134	54	56	7,200
Taiwan	0	2,906	4,295	0	0	12	93	7,306
S. Asia	0	597	763	102	96	0	182	1,740
India	0	0	3	0	0	0	84	87
Pakistan	0	432	0	0	0	0	0	432
Bangladesh	0	165	268	102	96	0	98	729
Other	0	0	492	0	0	0	0	492
SE Asia	278	2,913	2,743	0	1,580	115	524	8,154
Indonesia	137	223	1,170	0	700	0	80	2,311
Malaysia	19	17	493	0	366	59	78	1,032
Philippines	57	2,057	742	0	365	0	0	3,221
Singapore	0	53	0	0	10	0	0	63
Thailand	65	537	332	0	139	57	320	1,450
Vietnam	0	26	5	0	0	0	46	77
Middle East	260	146	7,120	520	3,842	110	1,452	13,450
Africa	1,026	658	11,537	2,341	686	106	2,781	19,134
Latin America	216	20	26,813	1,290	1,922	182	11,066	41,510
Mexico	41	0	13,213	129	708	0	25	14,116
Caribbean	12	0	4,344	284	1	11	20	4,671
E.C. Cen America	0	0	596	0	0	26	0	622
W. C. Central America	39	0	2,476	0	0	0	122	2,637
E.C. S. America	0	0	345	16	215	30	8,380	8,986
W. C. S. America	85	0	3,445	75	700	116	1,283	5,703
Chile	0	20	838	0	216	0	1,044	2,119
Venezuela	40	0	1,555	786	83	0	192	2,655
Total Exports from Above	6,334	20,283	84,752	5,778	11,306	8,913	20,890	158,256
%	4	13	54	4	7	6	13	

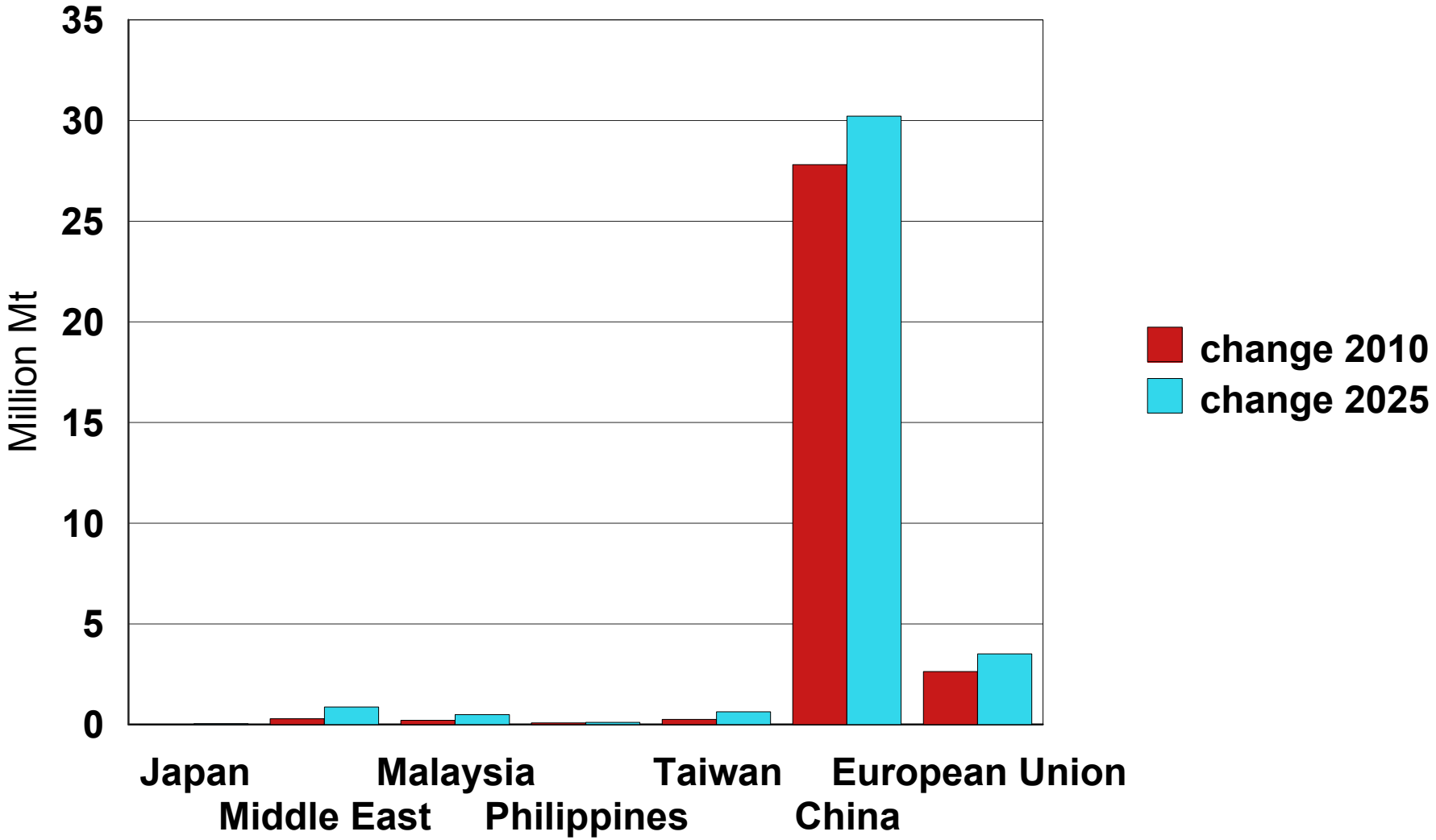
Demand/Consumption

- For each region/country of the world and grain
- Consumption functions
  - C/popn=*f*(income,trend)+e
  - non-linear to capture changing income elasticity and market maturity
- Estimated: non-linear/exponential
- Projection
  - inc, popn from WEFA
  - Generate point estimates of demand
- Import demand: Residual
  - *I=Consumption-Production*

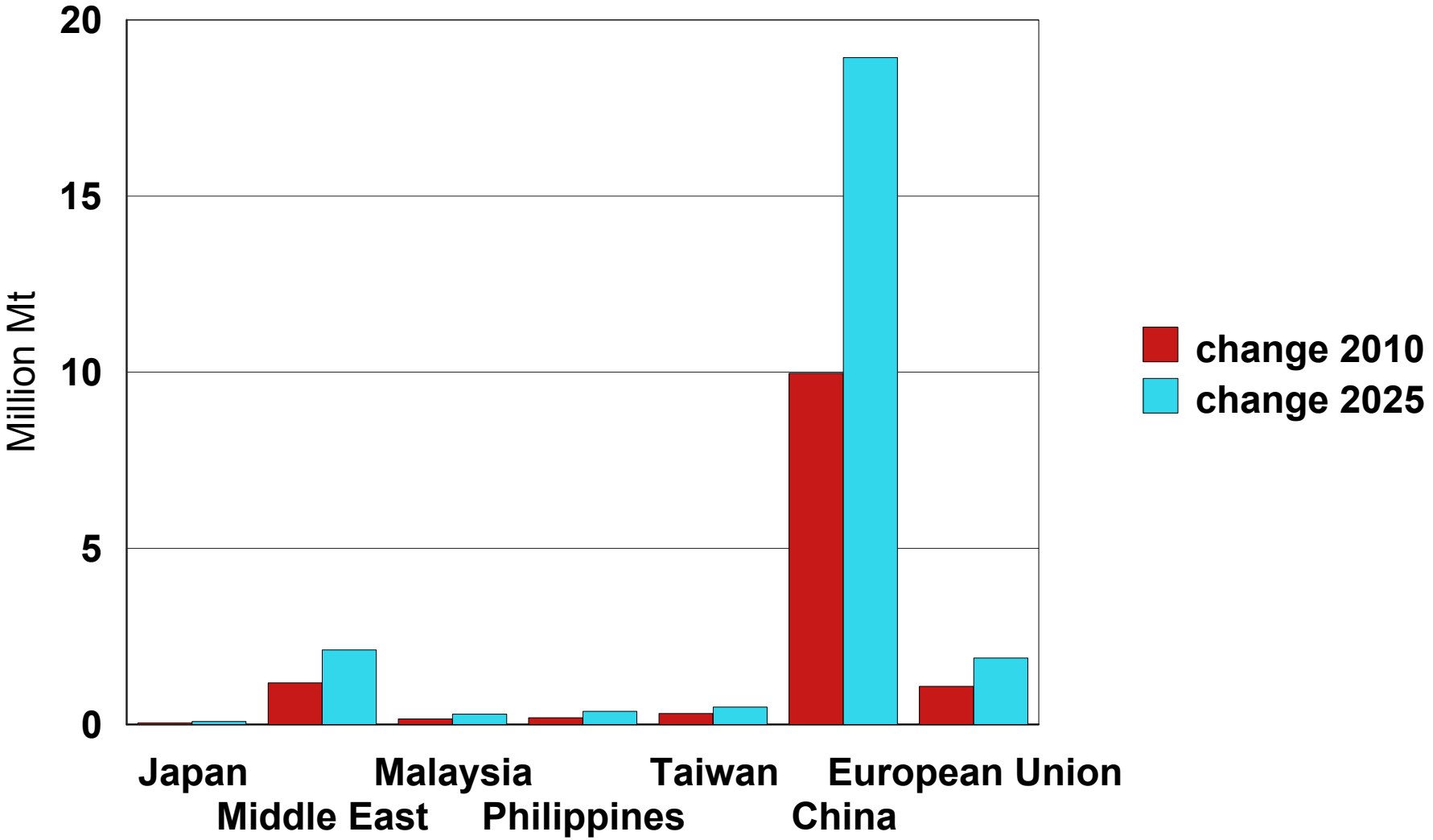
Total Import Demand, 2001-2025, All Grains



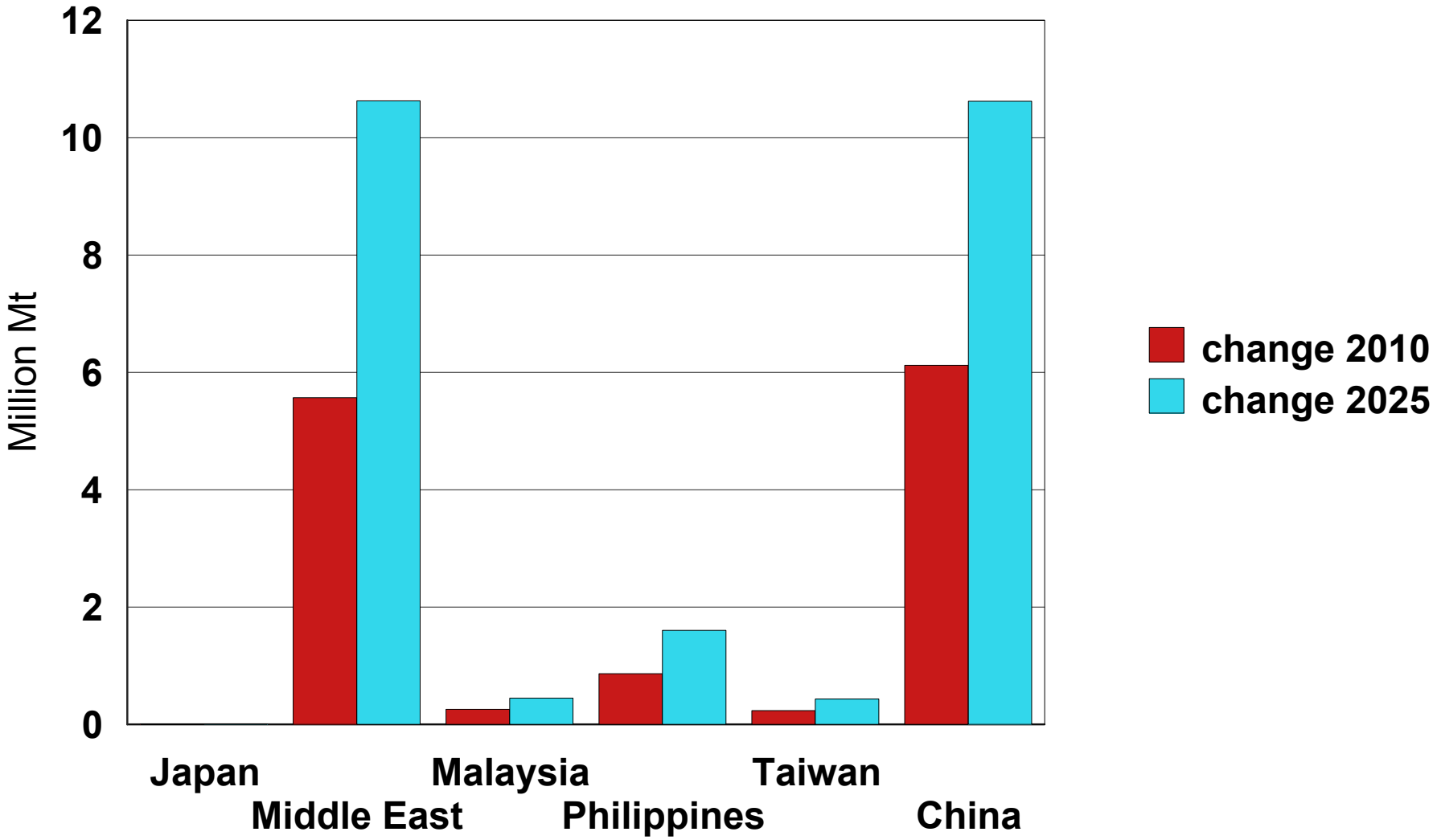
Increases in Import Demand, 2001-2010 and 2010-2025, Corn



Increases in Import Demand, 2001-2010 and 2010-2025, Soybeans



Increases in Import Demand, 2001-2010 and 2010-2025, Wheat



Big 3 Issues Impacting World Grain Trade:

- China: Consumption (amongst others)
- Ethanol
- Brazil

Fundamental I: China

- Summarized above

Fundamental II: Ethanol

- See below

Effect of Increase in U.S. Domestic Corn Demand for Ethanol

- Corn consumption will increase another 13% by 2010 and 11% by 2025, versus what would otherwise be natural consumption growth
- Most of growth in ethanol consumption will be concentrated in Central and Northern Plains, and the Western corn belt

Recent News Reports

- Milling and Baking News, Jan. 7, 2003
  - U.S. ethanol industry in Nov 2002 set a new monthly production record of 166,000 barrels per day according to US Energy Information Admin
  - Production was up 32% from Nov 2001 output of 126,000 barrels per day
  - Nine additional plants are under construction
- Renewable Fuels Assocation
  - Ethanol industry would produce more than 2 billion gallons in 2002. Currently 68 plants have the capacity to produce over 2.7 billion gallons annually

Recent News Reports

- Summary and Highlights of Pro Exporter Meeting in St. Louis, MO. Dec 8, 2002
  - Rich Feltes indicates demand of corn for ethanol is projected to increase by 1 billion bu (25 mmt) in the next 10 years.
    - However, 400 million bu of domestic demand for feed corn would be displaced by use of distillers dry grain
    - Net effect would increase demand for corn by 600 million bu or about 15 mmt

Another Recent Report Indicated

- ProExporter Network to the Dec 2002 National Grain and Feed Association's Grain Elevator Council Meeting in St. Louis, MO (presentation by William Hudson) as reported in Grain Journal, p. 172
  - If demand for ethanol rises to 5 billion gallons per year, roughly double today's demand and anticipated under proposals for a federal renewable fuels standard, the U.S. will need another 40 or 50 ethanol plants.
  - Doubling of demand also will divert another 1 billion bushels of corn to match the same billion bushels devoted to ethanol production today.
  - Whatever the federal policy on renewable fuels, sooner or later, liquid fuels from plant sources will become a necessity, simply because known Middle East reserves of petroleum will begin to run out in 30 to 50 years.

2003 USDA Outlook Conference

- U.S. currently has 2.7 billion in ethanol capacity, with 11 plants under construction that will add an additional 483 million gallons of capacity.
- 13 more plants are on the drawing table to begin this year.
- Most of recent construction are undertaken by farmer-owned operations.
- Over 1 billion bushels of corn will be used to produce ethanol in 2003/04 and this approaches 2 billion bushels by the end of the decade.

Estimated Change in 2010 Corn Consumption Due to Increased Ethanol Production Region

	Demand with No Addition for Increased Ethanol	Added Demand for Ethanol	Total Demand with Ethanol Increase	Increased Ethanol as Percent Demand
Central Plains	27,622	6,565	34,187	19
Delta	7,830	0	7,830	0
Eastern Corn Belt	65,467	2,243	67,710	3
North East	8,917	404	9,321	4
Northern Plains	9,135	5,214	14,349	36
Pacific Northwest	1,957	17	1,974	0
South East	20,445	67	20,511	0
Southern Plains	11, 527	543	12,070	4
West Coast	6,090	4,693	10,783	43
West Central	58,942	8,319	67,261	12
TOTAL	**216,932**	**28,063**	**245,996**	11

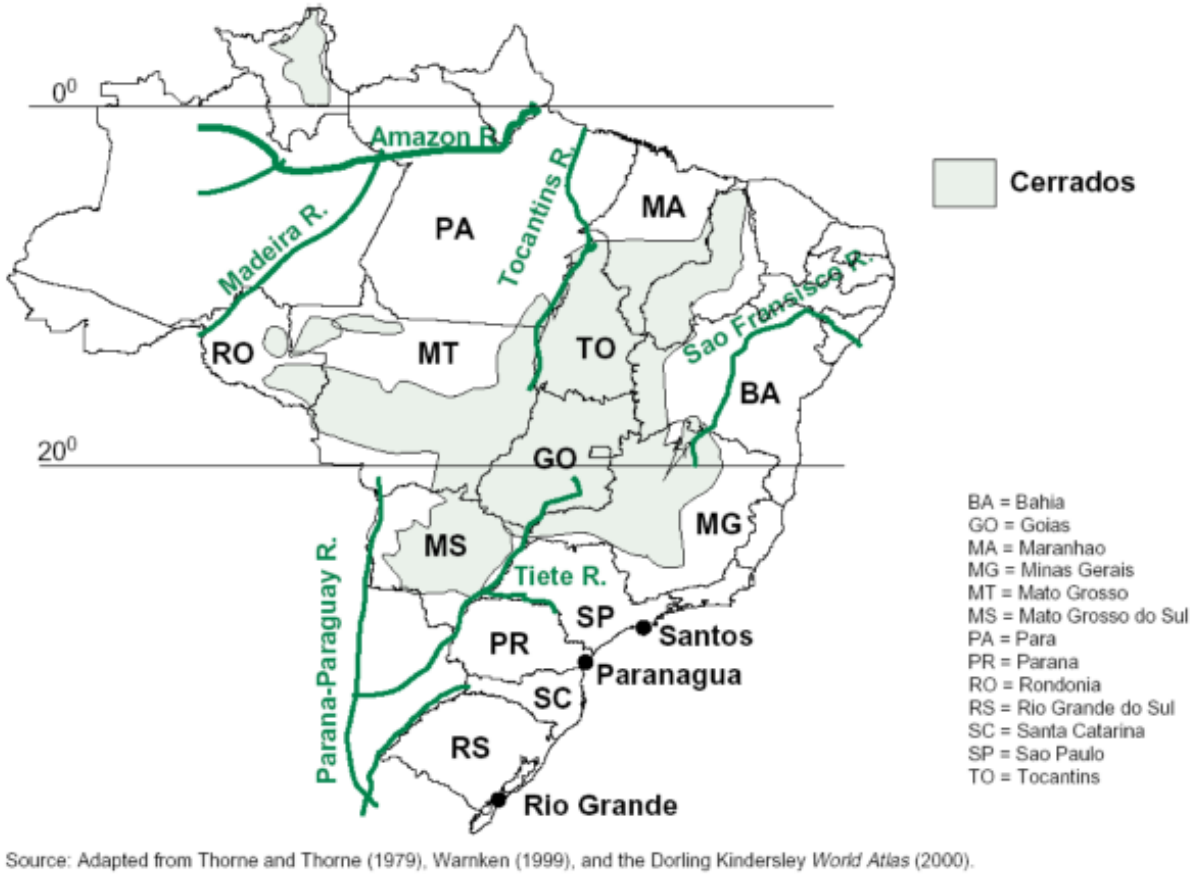
Fundamental III: Brazil

- FAPRI and others way underestimate role/impact of developments in Brazil (Baumel)
- Major supplier of
  - Soybeans
  - Corn
- 2 Fundamental Changes (prospective)
  - Increase in production
    - Yields
    - RR adoption
    - New Lands
  - Transport projects..
    - reduce costs
    - change channels to/through the North

Changes in Brazil Soybean Production

- Production is expected to increase from 31mmt in 1999 to 44 mmt in 2005 (41%) to 108 mmt by 2020 (250%)
- Most of increase due to prospect of increasing area under production
- Increase is expected to be concentrated in the Northerly states in Brazil (representative of Matto Grosso and north)

Brazil Production Regions



Source: Adapted from Thorne and Thorne (1979), Warnken (1999), and the Dorling Kindersley *World Atlas* (2000).

Figure 2.2.1 Brazil Production Regions.
Source: Adapted from USDA-ERS WRS 01-3, Schnepf, Dohlman, and Bolling.

Brazil Production Potential

State	Production 1999	Estimated Production 2005	Estimated Production 2020	% Change 2005	% Change 2020
Rondonia	16	160	7,004	144	6,988
Acre	0	0.4	0.9	0	1
Amazponas	2	2.9	35.2	1	34
Roraima	0	1.9	86	2	86
Para	3	23.8	3,594	21	3,591
Tocantins	113	283	3,527	170	3,414
Maranhao	409	791	3,103	382	2,694
Piaui	83	229	2,215	146	2,132
Bahia	1,150	2,333	6,363	1,183	5,213
Minas Gerais	1,339	1,811	3,396	472	2,057
S Paulo	1,421	1,193	896	-228	-525
Parana	7,756	8,619	11,826	863	4,070
Santa Catarina	472	638	1,359	166	887
Rio Grande do Sul	4,466	5,909	8,669	1,443	4,203
Mato Grosso do	2,799	3,786	7,669	987	4,870
Sul	7,473	11,516	26,469	4,043	18,996
Mato Grosso	3,419	6,406	21,984	2,987	18,565
Goias	66	108	137	42	71
Dis Fedearl					
Brazil	30,987	43,811	108,333	41	250
Brazil N	9,249	15,341	52,397	66	467
Brazil S	21,739	28,470	55,936	31	157

Taken from: Governo Federal "Corredores Estrategiocos de Desenvolvimento" Jan 2002

Exports of Soybeans Projected by Major Exporters

Exporter	2005	2020	Change	% Change
US	26.00	41.00	15.00	58
Argentina	4.80	9.80	5.00	104
Brazil	15.80	50.20	34.40	218
Canada	0.30	0.05	-0.25	-83
China	0.15	0.03	-0.13	-83
EU	0.40	0.72	0.32	80
Other (Americas)	3.15	5.30	2.15	68
Other	0.20	4.50	0.25	123
TOTAL	50.80	107.54	56.74	112

Projects Designed to Open the Amazon Waterway as a Conduit for Agricultural Products are Underway

Source: Economic Research Service, USDA.

Source: Adapted from USDA-ERS WRS 01-3, Schnepf, Dohlman, and Bolling.

Projects Underway, being Planned/Discussed

- Truck to Pto Vehlo, water to Itacoatiara and Santarem
  - Completed and utilized
- BR 163 - highway to Santarem
  - Currently paved to the Matto Grosso border
  - Further north, 50 bridges needed to complete project
- Tapajos Waterway - serving the Port of Santarem
  - Orginiating soybeans from very large productive area
  - Parallel to the BR163 project
- Other projects being planned

Comparative Shipping and Handling Costs to Rotterdam

Region	Origin		Road	RR	Barge	Terminal	Sub-Total	Ocean	Gr. Total
						2000 $/MT			
1 to North	Campo Novo do	PT VELHO-ITA	25	0	14	10	49	15	64
1 to Santos	Parecis	Santos		55		11	66	17	83
	Campo Novo do								
2 to North	Parecis	PT VELHO-ITA	38		14	10	62	15	77
2 to Santos		Santos	48			11	59	17	76
	Sorriso								
3 to North	Sorriso	Vitoria	10	23		11	44	17	61
3 to Santos		Santos	29			11	40	17	57
	Rio Verde								
4 to Santos	Rio Verde	Santos		21		11	32	17	49
	Campo Grande								
						2015 $/MT			
		C. Rast. Santerem	15	0	14	10	39	15	54
		Cuiaba-Santos	9	17		14	40	17	57
		C. Rast. Santerem	20		14	10	44	15	59
		Rio Vila do Conde	22		21	11	54	15	69
		Vitoria			31	11	52	17	59
		Santos		20		11	31	17	48
		Santos		20		11	31	17	48
									0

Comparative Shipping and Handling Costs to China

Region	Origin		Road	RR	Barge	Terminal	Sub-Total	Ocean	Gr. Total
						2000 $/MT			
1 to North	Campo Novo do Parecis	PT VELHO-ITA	25	0	14	10	49	35	84
1 to Santos	Campo Novo do Parecis	Santos		55		11	66	35	101
2 to North	Sorriso	PT VELHO-ITA	38		14	10	62	35	97
2 to Santos	Sorriso	Santos	23	20		14	57	35	92
3 to North	Rio Verde	Vitoria	10	23		11	44	35	79
3 to Santos	Rio Verde	Santos	29			11	40	35	75
4 to Santos	Campo Grande	Santos		21		11	32	35	67
						2015 $/MT			
		C. Rast. Santerem	15	0	14	10	39	35	74
		Cuiaba-Santos	9	17		14	40	35	75
		C. Rast. Santerem	20		14	10	44	35	79
		Rio Vila do Conde	22		21	11	54	35	89
		Vitoria			31	11	52	35	77
		Santos		20		11	31	35	66
		Santos		20		11	31	35	66

Major Changes/Implications

- Rapid expansion of soybean production in the Central and North of Brazil resulting in an expanded export supply
- Infrastructural projects involving reductions in the interior cost of shipping by $10/mt
- A prospective shift to result in increased exports from the Northern ports. Currently shipping costs from Mato Grossa via the northern ports have an advantage versus those going through the traditional Southern Ports
- Recent announcement
  - Port developed in the South at the Port of Santos to export up to 10 mmt/year
  - China investments to support expansion of Brazil transport infrastructure.
  - As these develop further, the prospect of shifting Brazil soybeans to Asia via the Canal will escalate

Spatial Equilibrium Model of World Grain Trade

- Modeling of flows, based on
  - Cost minimization
  - *Long-run competitive equilibrium*
- Objective:minimize costs of world grain trade, subject to
  - meeting demands at importing countries and regions,
  - available supplies and production potential in each of the exporting countries and regions,
  - production,shipping costs and technologies.
- The model is solved jointly for each of the 6 grains, _____ regions/countries and regions withn the US, Canada and Brazil.

Base Case Costs

- Production costs for each grain in each exporting region;
- Interior shipping and handling cost for each grain in each exporting region;
- Ocean shipping costs;
- Canal tolls for shipments through the Panama Canal.
- Base case uses values for the 2000/01 world crops marketing year.

Model Logic

- Domestic Demand Estimated/Projected
  - by grain, country and region
- Import Demand Determined
- Trade Flows Modeled to
  - Minimize Costs
  - i.e., identify least cost (as defined below) flows
- Subject to constraints
  - Area that can be brought into production by regions, which combined with yields determines production
  - Trade policy/preference constraints

Constraints Imposed on Model: Market and Trade Policy Restrictions

Exporter	Importer	Grain	Restriction	Reason	Impact	Duration
US	Cuba	All grains (rice)	No trade	Trade policy restriction	Maintained assumption. Rice is imported from China	Relaxed in 2005 forward
US Ethanol	none	corn	none	Accelerated expansion. Reduced exportable supplies concentrated in western regions	Exports favored from eastern regions through US Gulf to Asia, versus US PNW	Commencing in base case with existing production; expanding in 2010
US West Coast	China	Wheat	Not allowed	TCK Smut	Forces China wheat to US Gulf–relax in 2005	Relaxed in 2005 forward
US/Canada West Coast	Japan ,Korea, Philippines, Singapore, Thailand	Wheat	Only allowed from West Coast N. America despite higher cost	Quality requirements	Disallows Gulf to these Asian markets at lower cost	Maintained
Australia	Japan ,Korea, Philippines, Singapore, Thailand	Wheat	Max shipments only allowed at recent values	Quality requirements	Forces hard wheats from N. America. No direct impact on Canal	Maintained
Argentina, India	Japan ,Korea, Philippines, Singapore, Thailand	Wheat	No shipments allowed	Quality requirements	Forces hard wheats from N. America. No direct impact on Canal	Maintained
E Europe	Japan	Wheat	No shipments allowed	Quality requirements	Forces hard wheats from N. America. No direct impact on Canal	Maintained
China	Korea	Corn	Imports of 3 mmt	Reflect recent trade	Reduce exports from US Gulf/Canal	Maintained
US West	Japan, Korea, China	Corn	PNW shipments restricted to 4.2, 1.9 and 1 mmt, base case actual values	Reflect trade and likely that ocean rate differentials are less than occur in practice	Reduce exports from US Gulf/Canal	Maintained
US and Arg	EU	Soy beans	Minimizes US/Arg to EU, thus, making Brazil dominant supplier to EU	Reduces exportable supplies for Canal shipments to Asia	GM-free soybeans are required in EU and produced only in Brazil.	Relaxed in 2005 forward

Critical Factors Impacting Shipments--rank order

- Spatial distribution of agricultural supplies relative to demands
- Production costs in exporting regions
- Agricultural trade and marketing practicess
- Ocean shipping costs

Projections to 2025

- Variables forcast to 2025
- Critical variables: demand and yields
- Model solved and compared to base

Sequence of Changes in Factors Impacting Canal Grain Shipments

Grain/Factor	Timing	Effect	Most Likely- Pessimistic Optimistic Base Case
Demand growth due to population and income growth	Continual	Greater expansion for Canal shipments due to China	Projections and scenarios based on WEFA projections for income and population
Soybeans/GM in Brazil	2005	Shift soybeans from Brazil to EU to China, and replaced by US Gulf going to EU	Maintained assumption in all cases
Rice to Cuba	2005	Liberalized trade will shift Cuba rice to US, thereby reducing Canal shipments from Asia	Maintained assumption in all cases
Corn/ethanol	Continual, but accelerating in 2010	Reduced supplies for US PNW exports, shifting exports to Asia via the US Gulf and Asia	Maintained assumption in all cases
Brazil transport projects adopted	2010	Reduced shipping costs for northerly shipments	Adopted

Results Summary: All Grain Shipments by Exporter

	2001 NT	2001 T=2	2005 NT	2010 NT	2015 NT	2020 NT	2025 NT
Argentina	34,430	34,430	39,109	44,968	49,781	55,098	57,850
Australia	23,056	23,056	25,927	27,495	30,839	32,762	35,030
Brazil North	6,858	6,858	8,975	11,299	11,844	14,325	17,615
Brazil South	8,157	8,157	8,847	9,600	10,634	10,917	11,429
Canada East	1,326	1,326	1,366	1,469	1,653	1,718	1,966
Canada West	3,896	4,976	4,801	5,029	5,479	5,574	5,587
China	808	808	-	-	-	-	374
E. Europe	2,463	2,463	2,308	2,797	2,797	2,797	2,797
EU	29,458	29,458	33,323	37,124	42,812	49,509	55,331
FSU	10,583	10,583	9,150	8,774	11,041	13,496	15,221
India	3,603	3,603	4,008	4,008	4,008	4,008	3,910
Thailand	6,982	6,982	8,844	9,518	10,497	11,722	13,385
US East	17,537	17,435	18,397	18,842	18,388	18,601	19,501
US Gulf	64,370	63,392	67,090	77,209	79,903	83,318	89,330
US West	9,793	9,793	9,768	9,746	9,869	9,981	10,180
Vietnam	4,948	4,948	5,172	6,095	7,670	9,015	9,494

Results Summary: Corn Shipments by Exporter

	2001 NT	2001 T=2	2005 NT	2010 NT	2015 NT	2020 NT	2025 NT
Argentina	9,847	9,847	9,587	11,969	12,055	12,055	12,055
Australia	112	112	112	112	112	112	112
Former Soviet Union	1,515	1,515	1,515	1,515	1,515	1,515	1,515
US Gulf	39,351	39,351	42,816	51,353	51,285	53,847	56,339
US West	8,100	8,100	8,100	8,100	8,100	8,100	8,100

Results Summary: Soybean Shipments by Exporter

	2001 NT	2001 T=2	2005 NT	2010 NT	2015 NT	2020 NT	2025 NT
Argentina	10,076	10,076	13,240	14,354	16,911	20,041	20,400
Brazil North	6,858	6,858	8,959	11,204	11,644	14,010	17,178
Brazil South	8,157	8,157	8,828	9,481	10,382	10,521	10,875
Canada East	519	519	539	623	798	853	900
India	24	24	97	97	97	97	-
US East	7,000	7,000	7,000	7,000	7,000	7,000	7,000
US Gulf	16,046	16,046	14,332	14,150	16,709	17,243	19,877

Results Summary: Wheat Shipments by Exporter

	2001 NT	2001 T=2	2005 NT	2010 NT	2015 NT	2020 NT	2025 NT
Argentina	13,578	13,578	15,041	16,568	18,393	20,297	22,280
Australia	17,020	17,020	18,115	19,202	22,059	23,324	25,835
Canada East	777	777	795	814	828	843	1,049
Canada West	3,596	4,574	4,801	5,029	5,040	5,081	5,093
East Europe	2,463	2,463	2,308	2,797	2,797	2,797	2,797
Europe Union	25,096	25,096	28,006	30,882	35,841	41,848	47,015
Former Soviet Union	4,122	4,122	3,954	3,786	4,822	6,280	7,313
US East	10,215	10,215	10,451	10,689	11,034	11,306	11,657
US Gulf	4,340	3,363	5,959	8,015	8,205	8,463	8,734
US West	679	679	608	539	638	723	830

Synthetic Demand: Canal Shipments Under Various Tolls

Toll ($/mt)	Base Year	Base Year	2010	2010	2010	2010
	Canal Shipments for Grain (mmt)	Total Revenue ($million)	Canal Shipments for Grain (mmt)	Total Revenue ($million)	Canal Shipments for Grain (mmt)	Total Revenue ($million)
0	47.7	0	62.5	0	64.6	0
1	44.3	44.3	60.0	60.0	51.5	51.6
2	35.8	71.6	45.4	90.9	47.1	94.3
3	25.6	76.7	31.4	94.1	32.8	98.5
4	19.4	77.6	17.2	68.7	19.8	70.0
5	13.2	65.9	7.3	36.6	7.3	36.6
6	6.9	41.4	2.7	16.0	2.7	16.0

Synthetic Demands

- Long-run
- Considering impacts of
  - intermarket
  - intermodal
  - intercommodity
- Likely relevant for infrastructure planning vis a vis shorter-run elasticities

Discussion/Lessons

- Intensive detail
  - Reasonable results
  - Useful for project planning and projections
- Inability to evaluate uncertainties--efficiently
  - China--consumption
  - Ethanol
  - Brazil--prod expansion, cost and transp projects
  - Yield growth rate and uncertainty
  - FSU production/exports
  - Interior modal competition (PNW vs USGulf)

ACE Model Revisions/Plans 1

- Aggregate Importing Countries
  - Regions
    - Africa: North and Other
    - South and Latin America: Mexico, West coast, and other
    - Europe: EU 15 or EU25
    - S. Asia
    - South East Asia
    - Middle East
    - FSU
  - Individual Countries
    - US-by regions (see below)
    - Canada-by western province
    - Mexico
    - Brazil--North/South
    - Argentina
    - Australia
    - China
    - Japan
    - South Korea

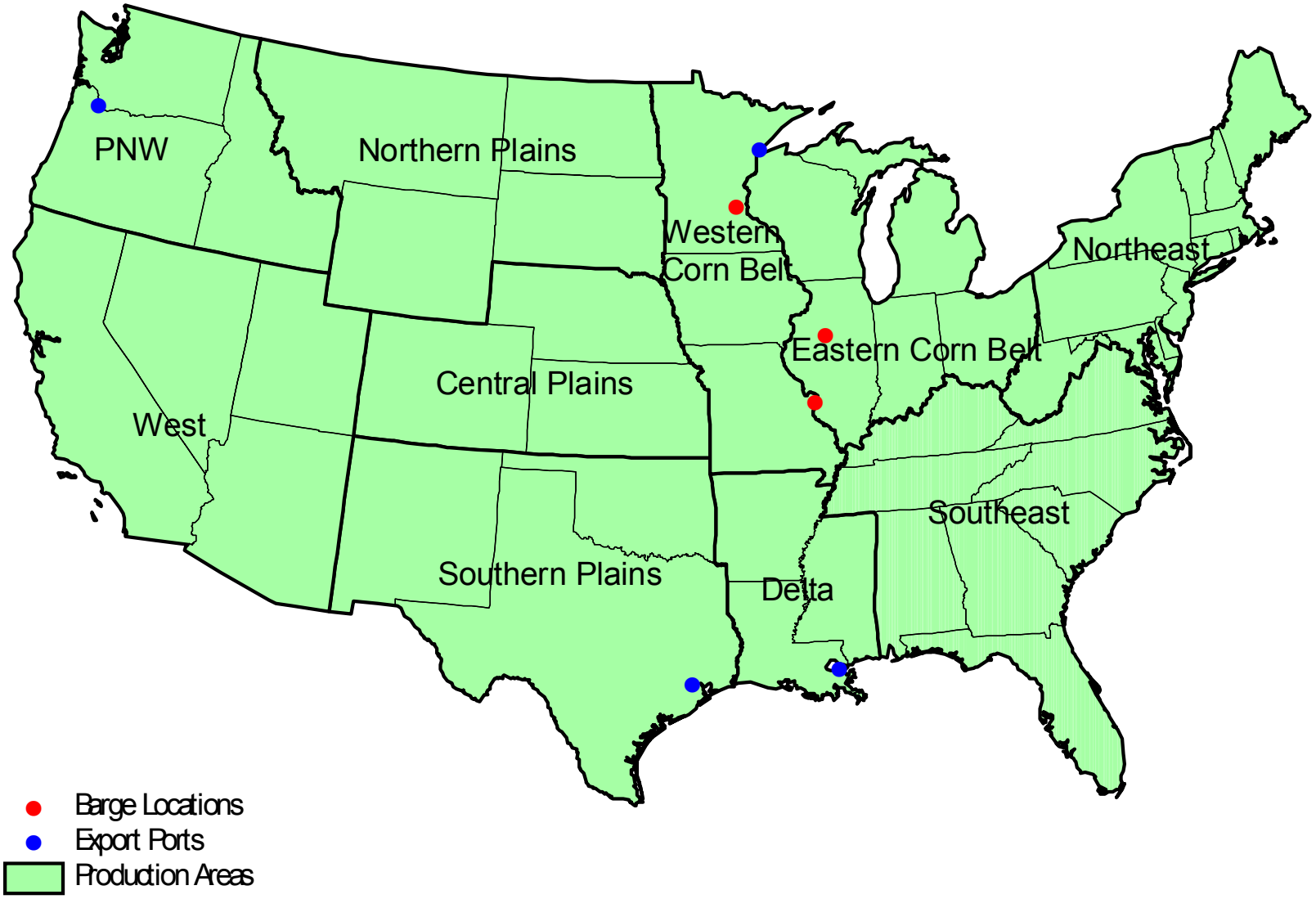
ACE Model Revisions/Plans 2

- Disaggregate prodcuing regions
  - Brazil: North vs South
  - United States
    - Alternatives
      - USDA production regions
      - Individual states
      - USDA production regions with selected states isolated
        - which states
      - Other
    - Issues

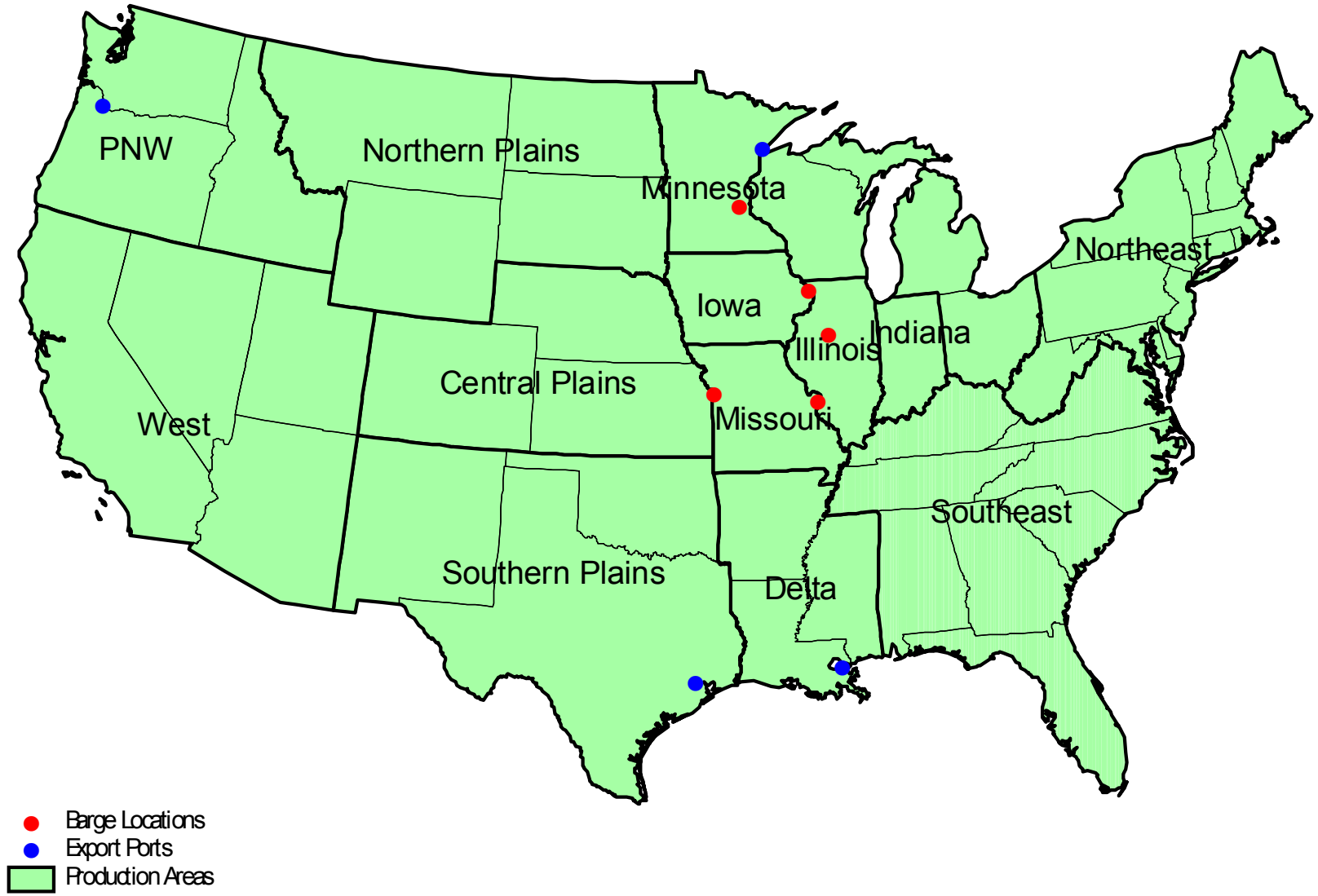
ACE Model Revisions/Plans 3

- Barge Transshipment Shipping Origins
  - Production regions
    - USDA
    - Confirm with WEFA for costs
    - Break out individual states in the Upper MIss region
  - Barge Loading stations
    - 5-6 origins relevant throughout
  - Competing shipping alternatives to Gulf
    - Rail direct
    - Rail to StLouis
    - Truck to barge shipping stations, barge to Gulf

USDA Production Regions



Alternative Production Regions



ACE Model Revisions/Plans 4

- Barge Delay Function and Capacity
  - Barge delay function
    - Added cost as/when barge shipments exceed critical levels
    - Reflective of barge operations/congestion
  - Alternative1
    - Use ACE estimates of barge delay functions
    - Econometrically determined relationship between barge rates and export levels (see below
- Capacity constraints
  - Add capacity constraits for river system--upper/lower
  -

ACE Model Revisions/Plans 5

- Ocean shipping costs
  - Estimated rate functions of
    - Distance
    - Oil prices
    - ship size
  - IGC data
  - DIfferential: Focus on Gulf/PNW spread

ACE Model Revisions/Plans 6

- Model: Spatial Linear Programming
- Callibration and Hind-caste
  - Deterministic verison of the spatial Optimization model used to evaluate and calibrate its efficacy relative to actual flows, i.e., back-caste (or hind-caste).
  - Identify crucial variables that change over time (ocean shipping costs, production and demand by region, etc).
  - Assemble historical observations for the back-caste period.
  - Solve the problem for each of the periods, and evaluate how the projected (minimum cost) flows through the US Gulf compare with actual shipments.
  - Time frame: 1994 to current by year.

ACE Model:Stochastic Optimization and Risk 1: Sources of Risk

- Variables: estimatoins error
  - yields (from a regression), y=f(t)+e
  - consumption...by importing country C=f(popn, income, t)+e
  - correlations amongst these
  - transport costs:
    - ocean shipping and Gulf/PNW spread
    - barges
    - rail
    - and their correlations, ...
  - Other potentially important stochastic (discrete or continuous) events
    - Development of Northern Brazil
    - FSU/EE production
    - GM adoption in wheat
    - Other
  - Forcasting error: chnages in underlying conditions (popn, gdp, etc)

ACE Model:Stochastic Optimization and Risk 2-1 Modeling RIsk

- Use scenario analyses to address forecasting errors, e.g., if population grows by 2% vs. 4%
- Estimation error can be addressed using
  - numerical integration,
  - mathematical programming and
  - simulation methods

ACE Model:Stochastic Optimization and Risk 2-2 Modeling RIsk

- Model Objective: Minimizing Expected Cost of satisfying consumption demands
- Programming method used to determine based on results needed
  - Point estimate of transportation flows
  - Range of transportation flows
  - Mean and variance of transportation flows
  - Predicting impact of increasing transportation capacity by X%

ACE Model:Stochastic Optimization and Risk 2-3 Chance-constrained programming

- Allows for constraints, such as satisfying demands and capacity constraints, to be violated less than X% of the time
  - e.g., capacity required to meet shipments 90% of time; 99 % of time, etc
- Allows for the measurement of the trade-off between reliability and cost
- Cost-minimization with Unconditional Systematic Sensitivity Analysis
  - Incorporate risk through joint distribution of estimation errors
  - Can derive confidence intervals around results
  - Can derive an estimate of the range of outcomes

ACE Model:Stochastic Optimization and Risk 2-4 Potential Programm. Methods

- Monte Carlo Simulation
  - Advantages
    - Large number of random variables
    - Number of model evaluations does not increase with number of random variables
    - Many alternative distributions for continuous and discrete random variables
    - Correlations amongst selected random variables
  - Disadvantages
    - Large sample sizes needed for any degree of confidence (40,000+) observations
    - Time consuming to evaluate model results
- Alternative: Quadrature
  - solves faster and use more moments

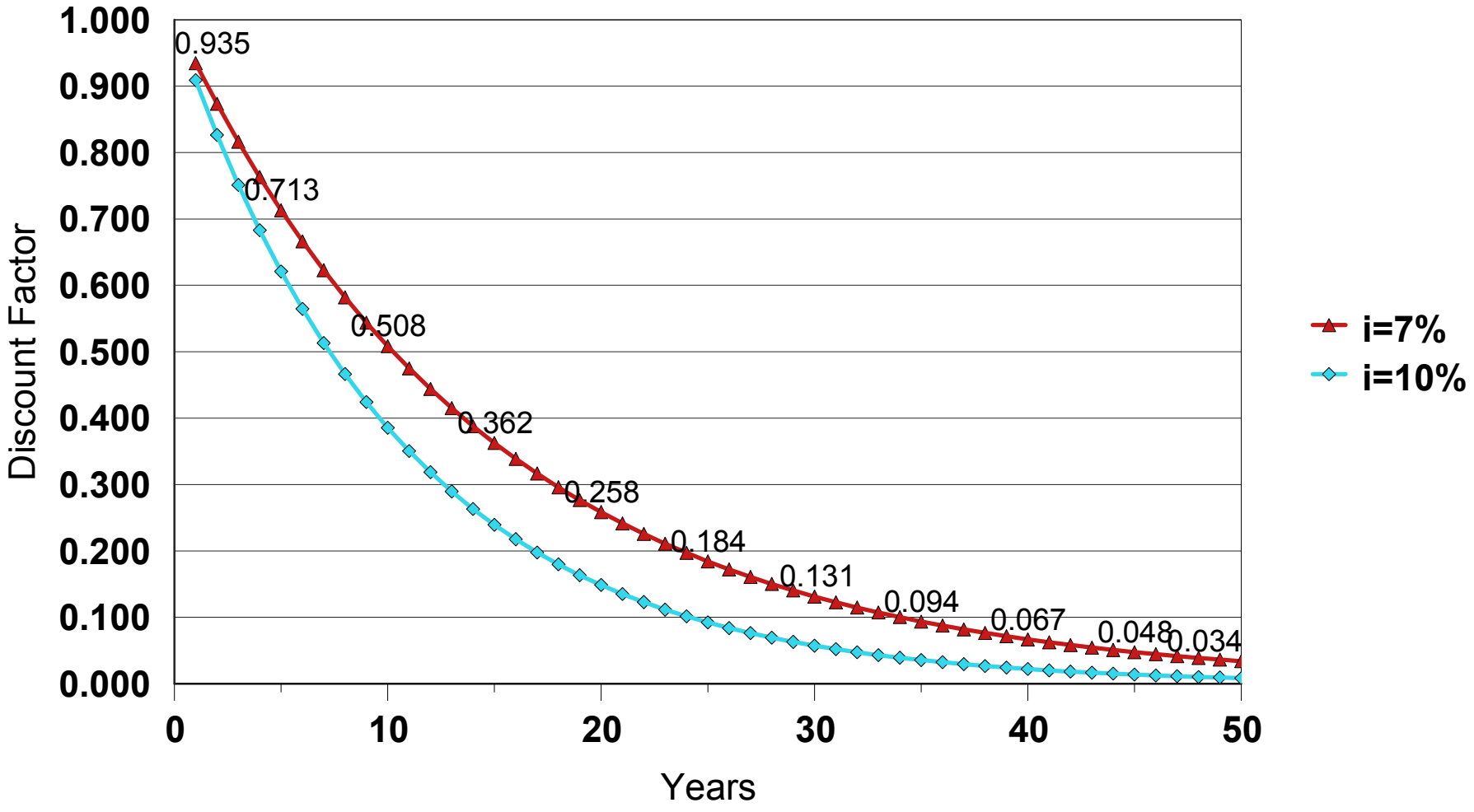
ACE Model:Stochastic Optimization and Risk 3-1

- Solution algorithm
  - GAMS
    - Optional solver DECIS (and others) which allow stochastic simulation and optimization as GAMS add-in
  - Reference: for comparison *Frontline Systems Premium Solver*
    - Problem created with relevant dimensions and distributions
    - 15 origins and 15 destinations
    - 2 hours to solve

ACE Model:Stochastic Optimization and Risk 4

- Planned output
  - Projections of flows (and production, consumption)
  - Emphasis on US Gulf and Upper Mississippi
  - Estimates
    - Point estimates in 10 year (or 5) increments
    - Risk measures: Min, max, std..
    - Distribution functtions
    - Evaluations: *Prob X> CV* where X is exports from Upper Miss and CV is a critical value
    - Others
  - Evaluation 1: How far foward is is practical/meaningful to make projections
    - Error structure increases in time
    - Discount rates diminishes importance of further distant projections and errors
  - Evaluation 2: Impacts of chance constraint
  - Evaluation 3: Scenarios on barge system
    - Derive synthetic demand for barge flows
    - Flows: WIth/with/out expansion in upper MIss.

Change in Discount Rate Over Time



Discount Factor

PV = FV [$1/(1+i)^N$]

Discount factor = [$1/(1+i)^N$]

which declines as time periods (N) increases

Present value of $1

- in year 30: $.13 (10*[$1/(1+.07)^{30}$
- in year 40: $ .07

ACE Model:Stochastic Optimization and Risk 5

- Data from ACE
  - Capacity on Upper Miss.--even if as a distribution
    - current
    - prospective
  - Map of flows/operating units
  - Potential intermodal elastiticies from concurrent studies
- Questions for ACE
  - What information is most critical to planning problem?
    - Point estimates?
    - Variances?
    - Ranges (low-high)?
  - What sources of risk are most critical to planning problem?
  - Are there other sources of risk?

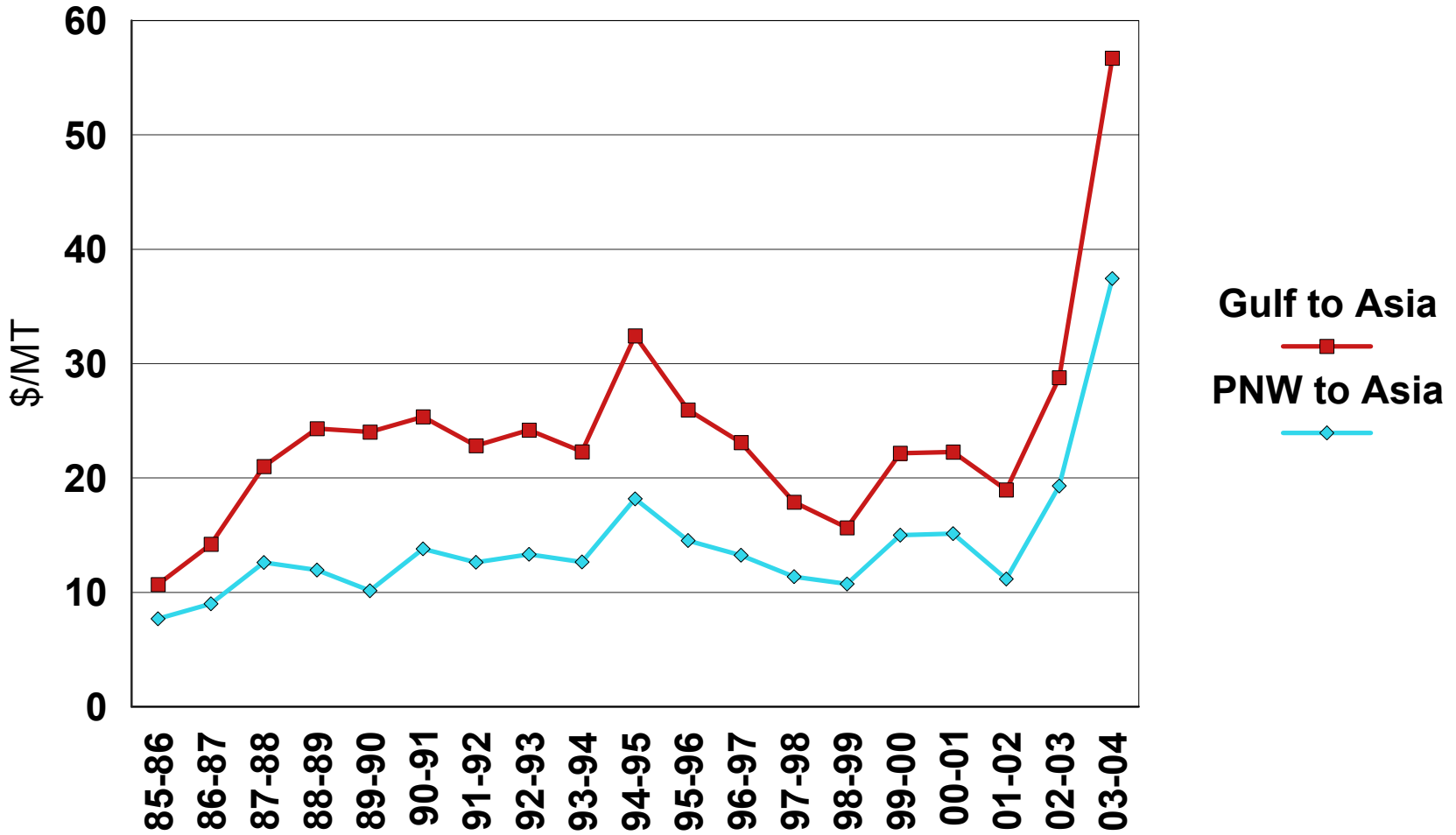
ACE Model:Stochastic Optimization and Risk 6

- Outstanding issues and outlook
  -

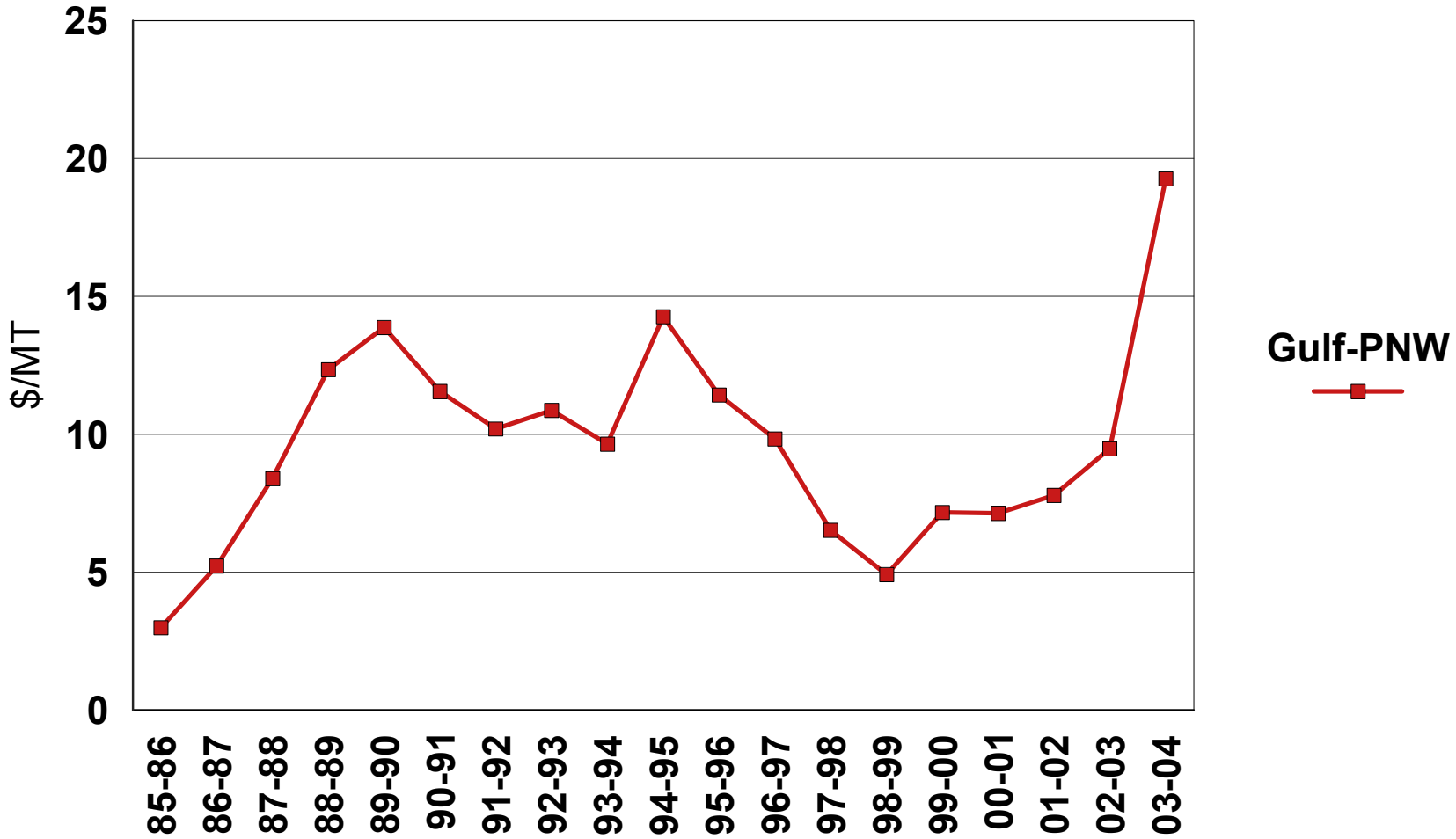
Data overview and Issues

- Initial data snapshot for illustration
- Organization
  - Modal rate relationships
  - World production/consumption (total)
  - Per capita consumption
  - Per capita consumption Estimation

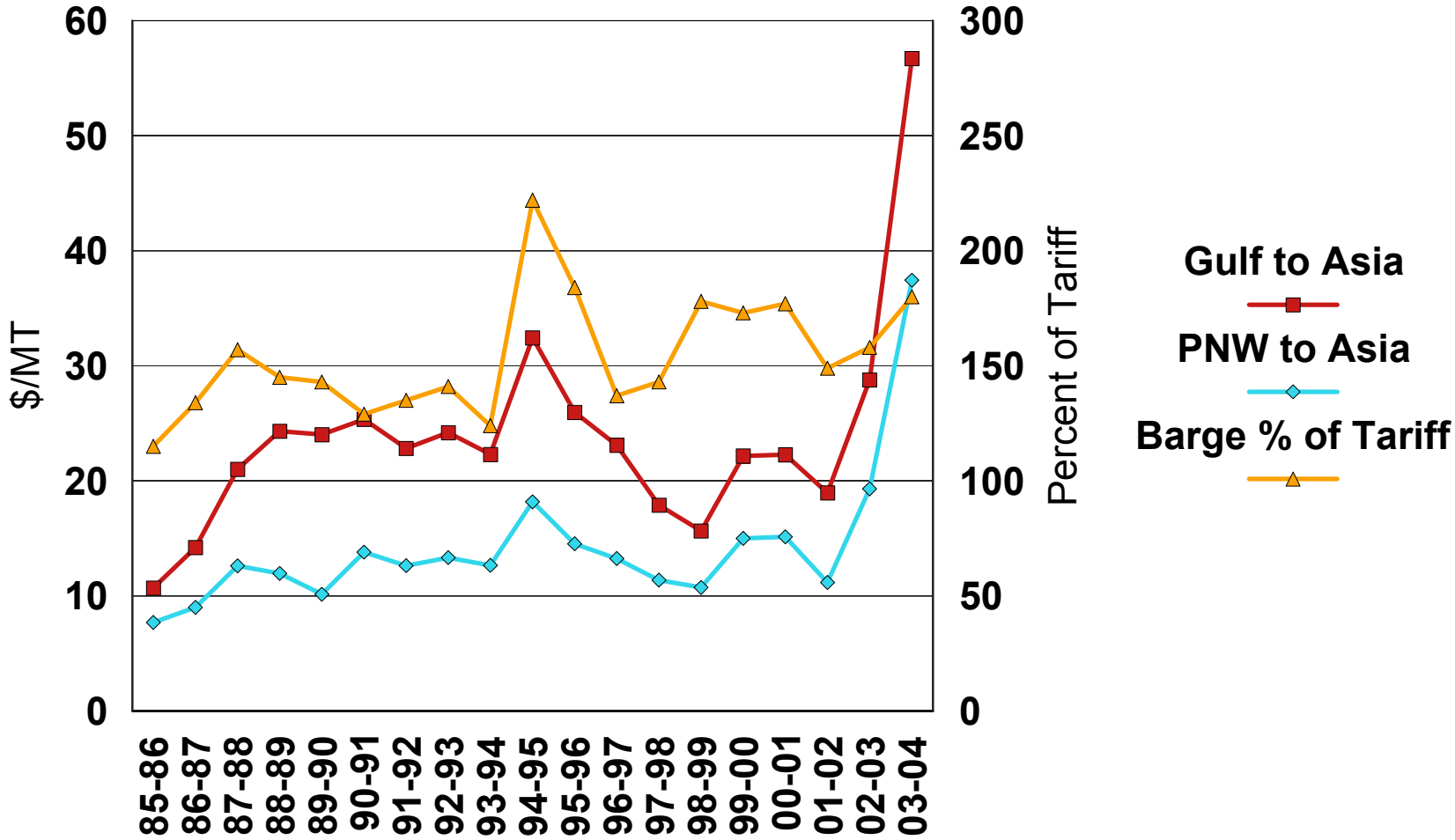
Comparison of Ocean Freight Cost to Asia (Gulf vs PNW)



Spread in Ocean Freight to Asia (Gulf-PNW)



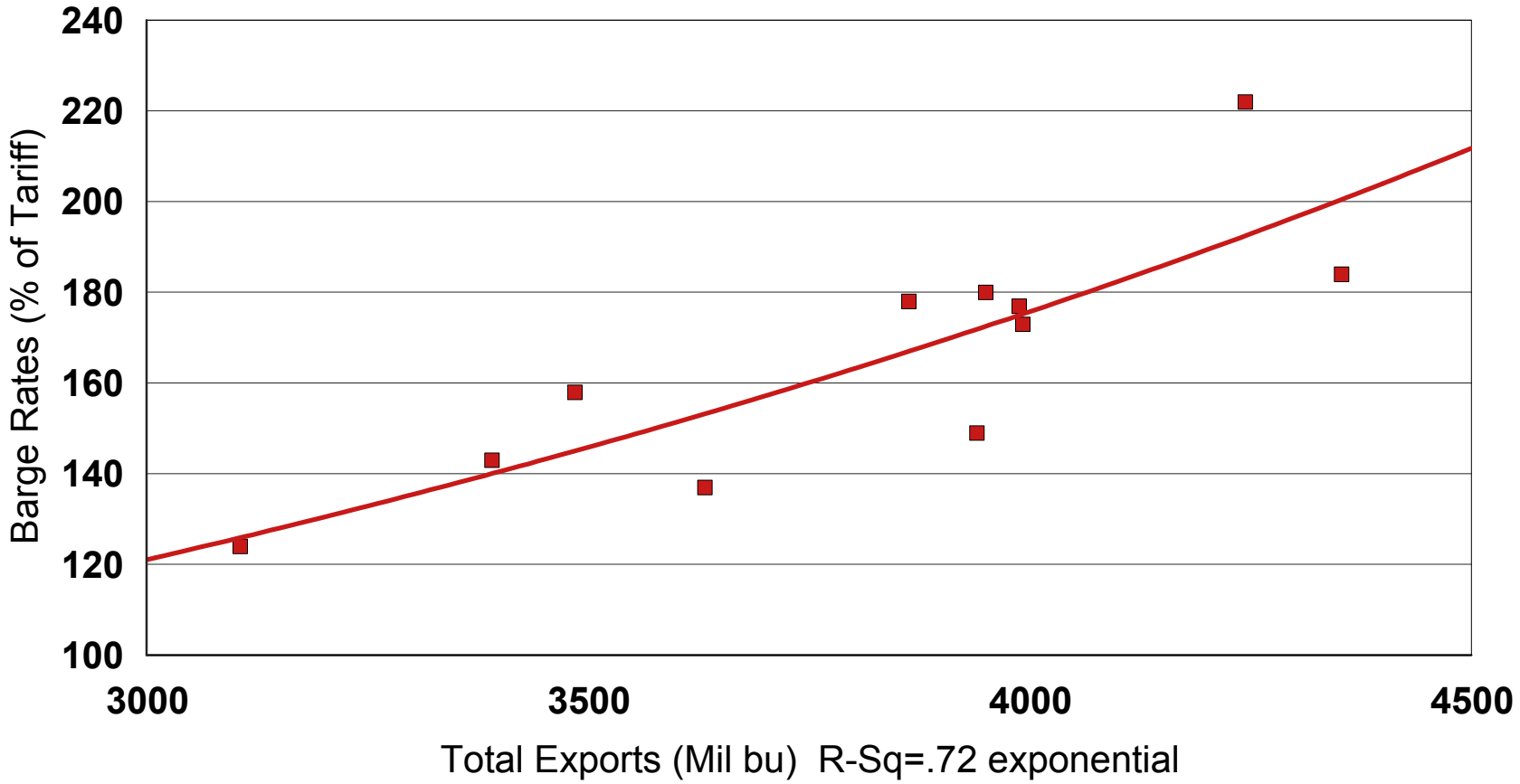
Ocean Freight to Asia (Gulf-PNW) and Barge Rates



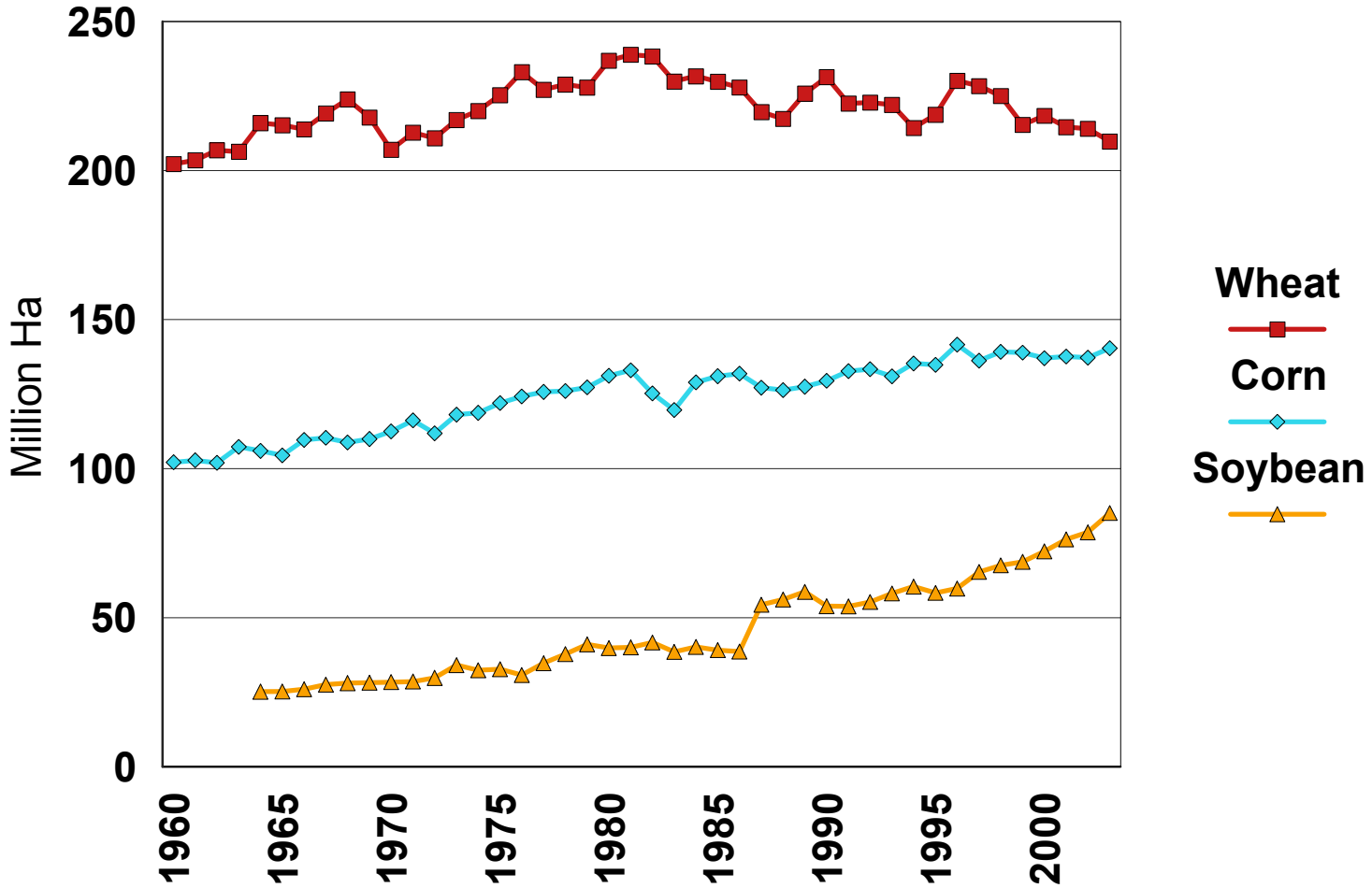
Correlation of Ocean Freight, Rail, Barge and Exports

	Barge		Spread			Exports			
	Gulf Asia	PNW Asia	Gulf-PNW	Rail	Barge	Corn	Soybean	Wht	Total
Gulf Asia	1.00	0.98	0.95	0.20	0.36	0.26	-0.14	0.16	0.21
PNW Asia	0.98	1.00	0.87	0.25	0.30	0.17	-0.07	0.06	0.13
Spread	0.95	0.87	1.00	0.10	0.44	0.40	-0.25	0.33	0.35
Rail	0.20	0.25	0.10	1.00	0.32	-0.16	-0.53	0.40	-0.22
Barge	0.36	0.30	0.44	0.32	1.00	0.76	-0.37	0.76	0.76
Corn	0.26	0.17	0.40	-0.16	0.76	1.00	-0.36	0.83	0.97
Soybean	-0.14	-0.07	-0.25	-0.53	-0.37	-0.36	1.00	-0.63	-0.21
Wht	0.16	0.06	0.33	0.40	0.76	0.83	-0.63	1.00	0.83
Total	0.21	0.13	0.35	-0.22	0.76	0.97	-0.21	0.83	1.00

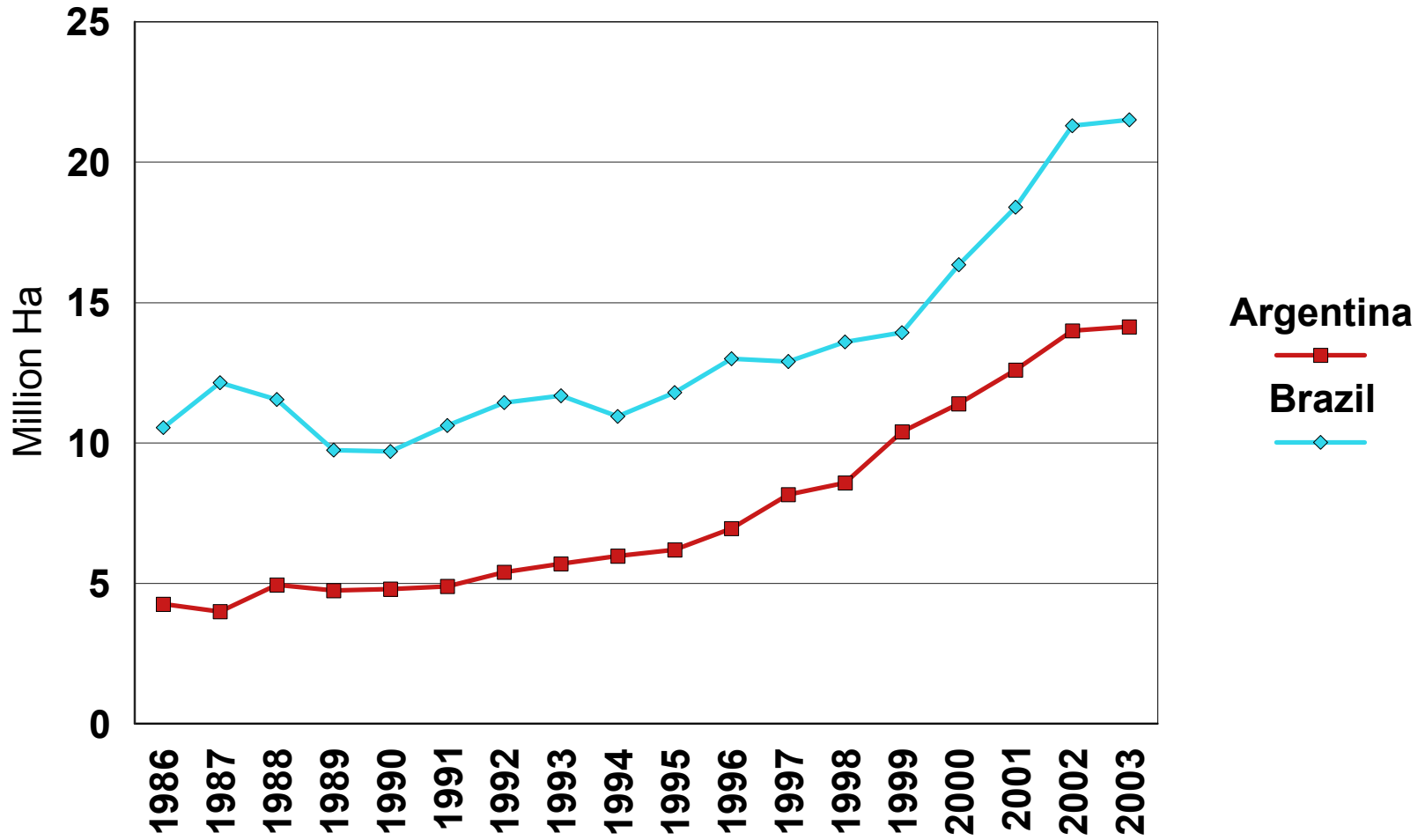
Comparison of Barge Rates and Total Exports (Corn, Soybeans and Wheat)



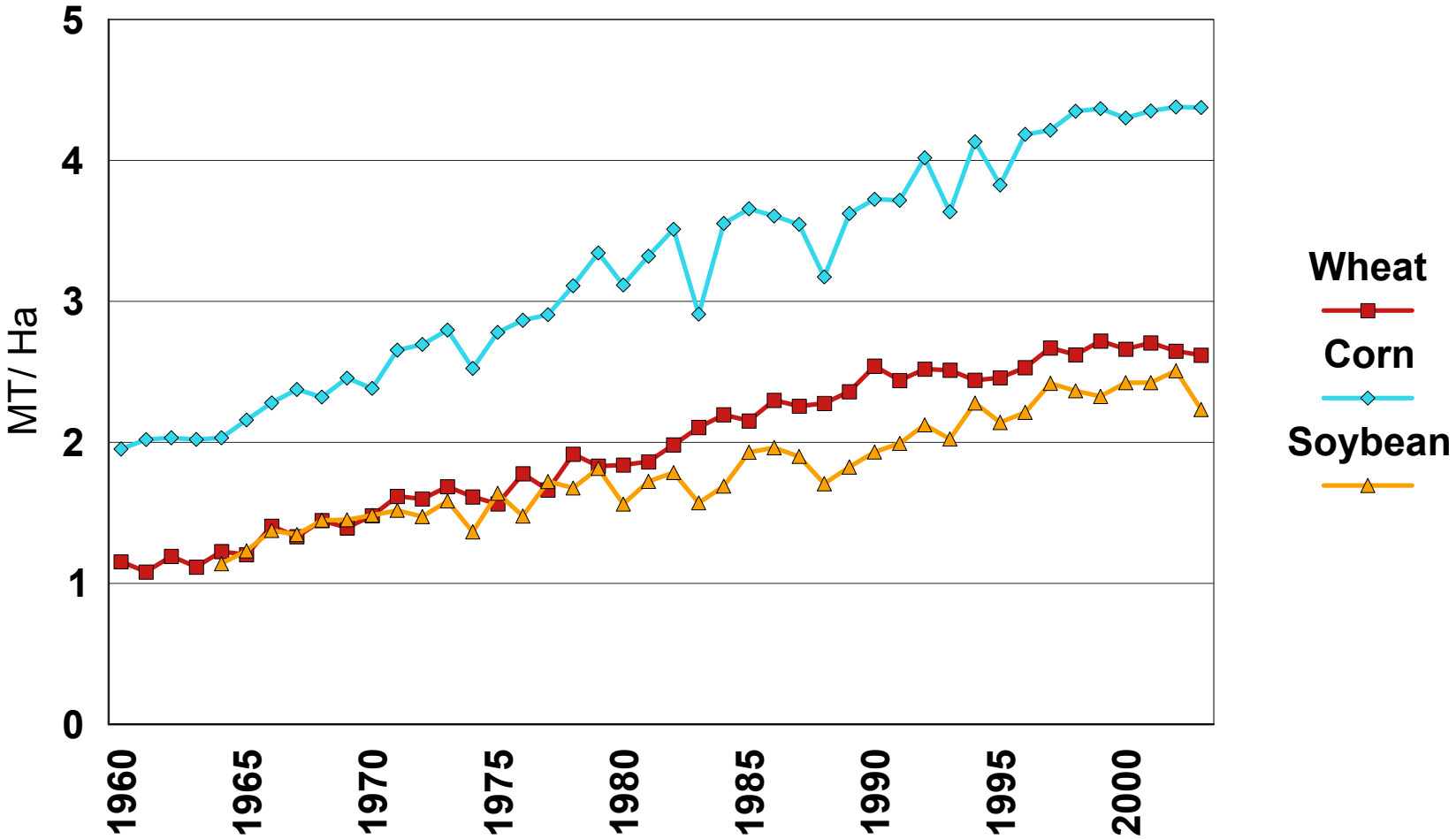
World Harvested Area



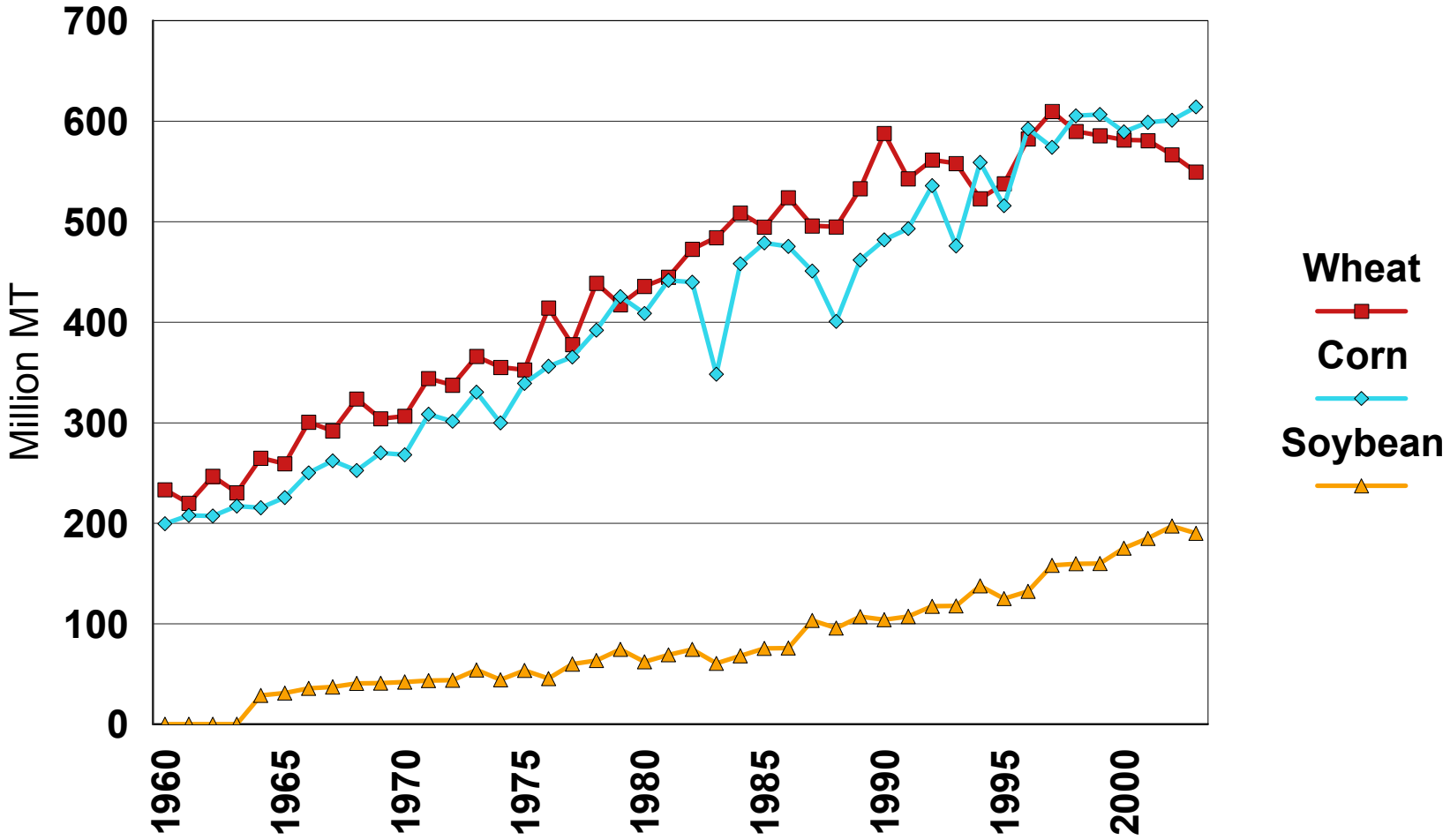
Soybean Harvested Area



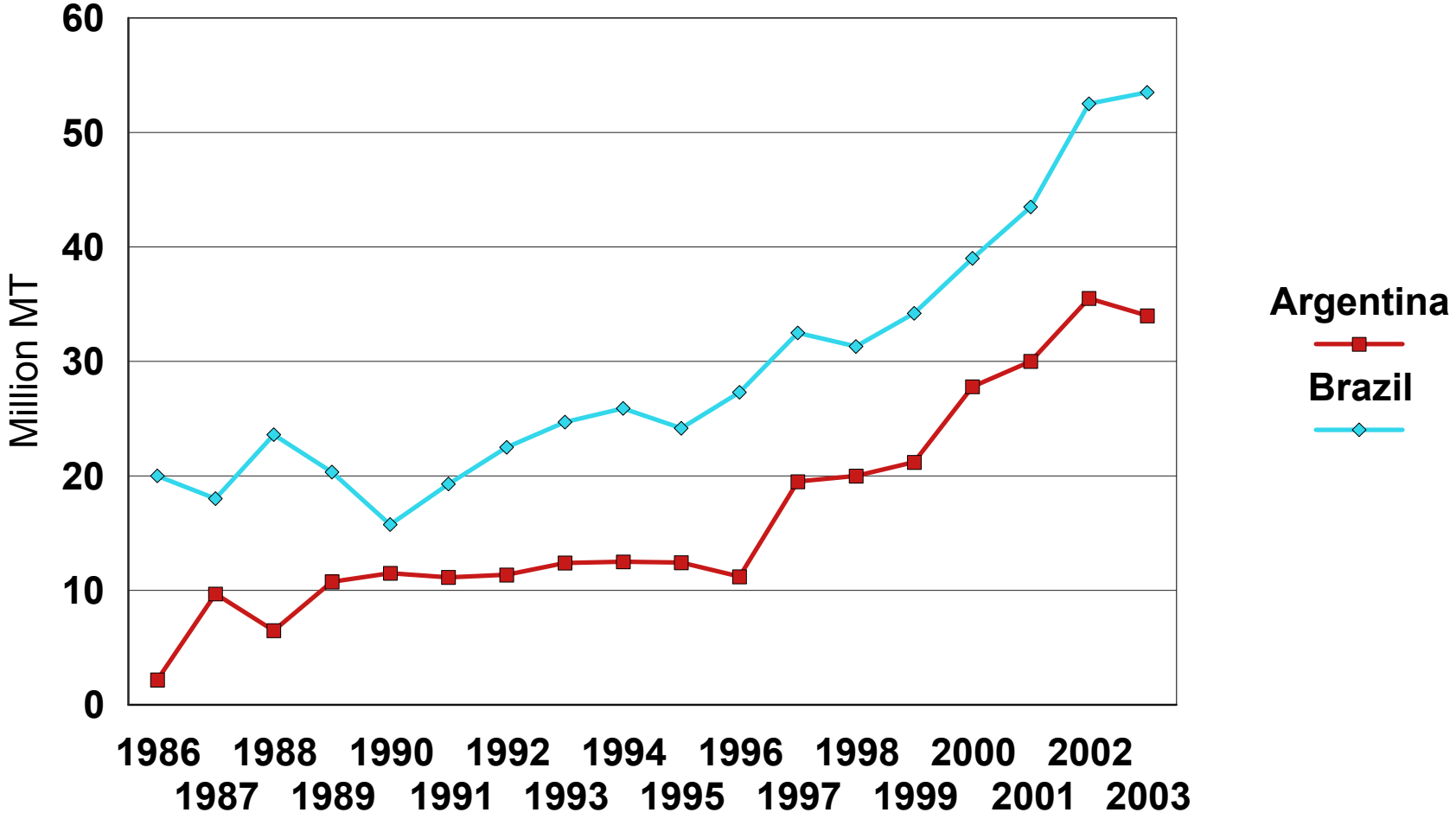
World Crop Yields



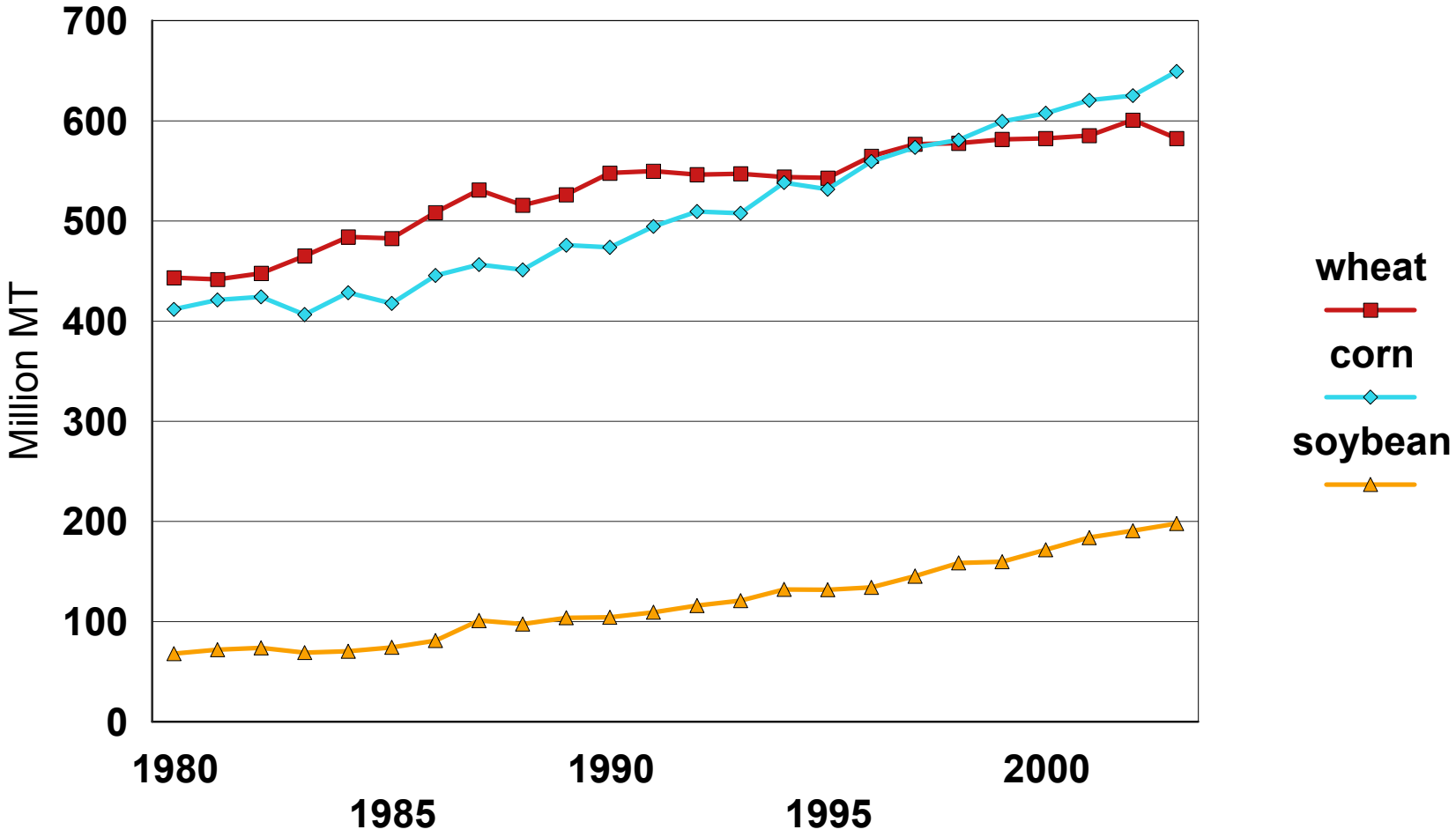
World Production



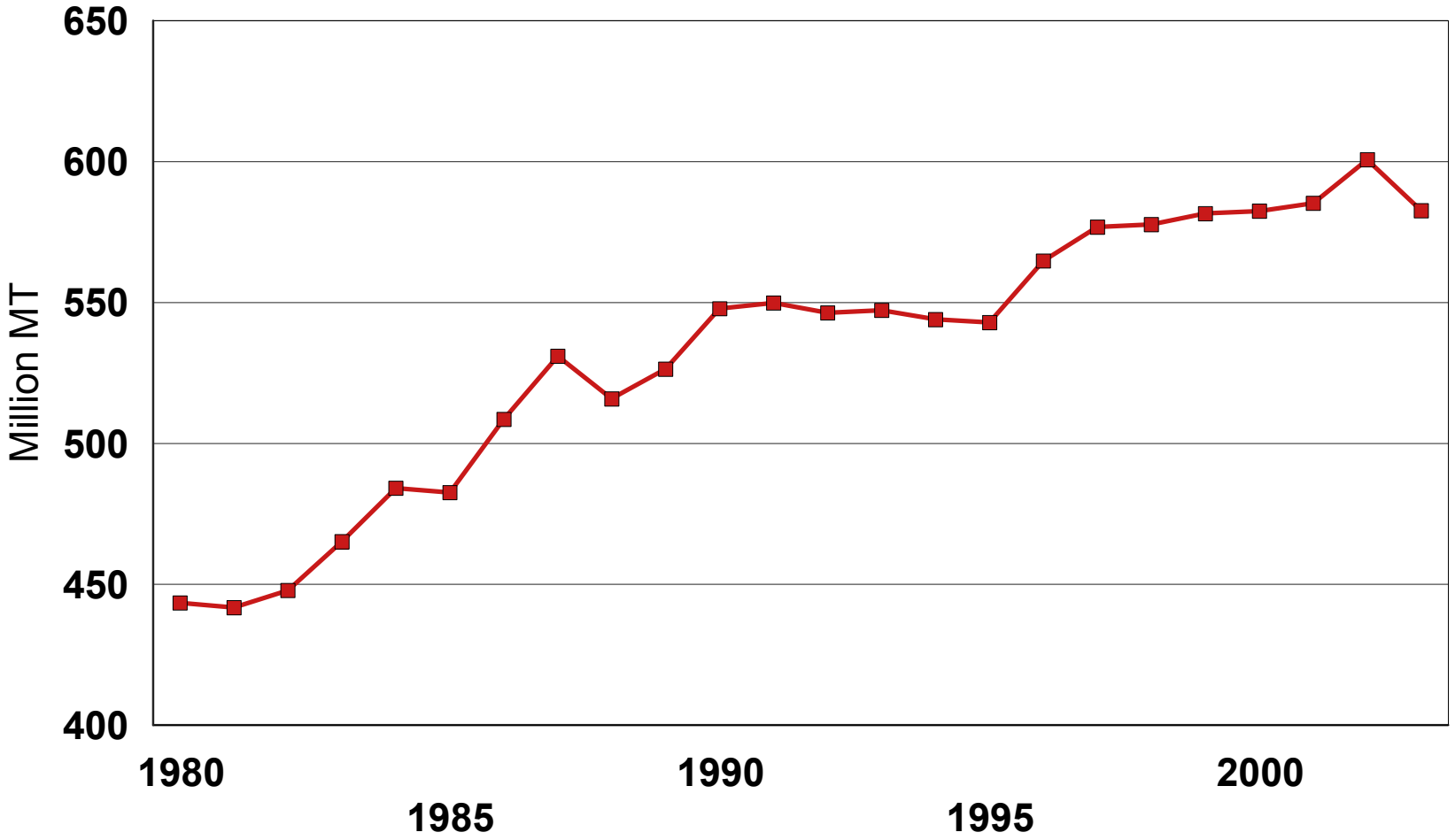
Soybean Production (Agentina and Brazil)



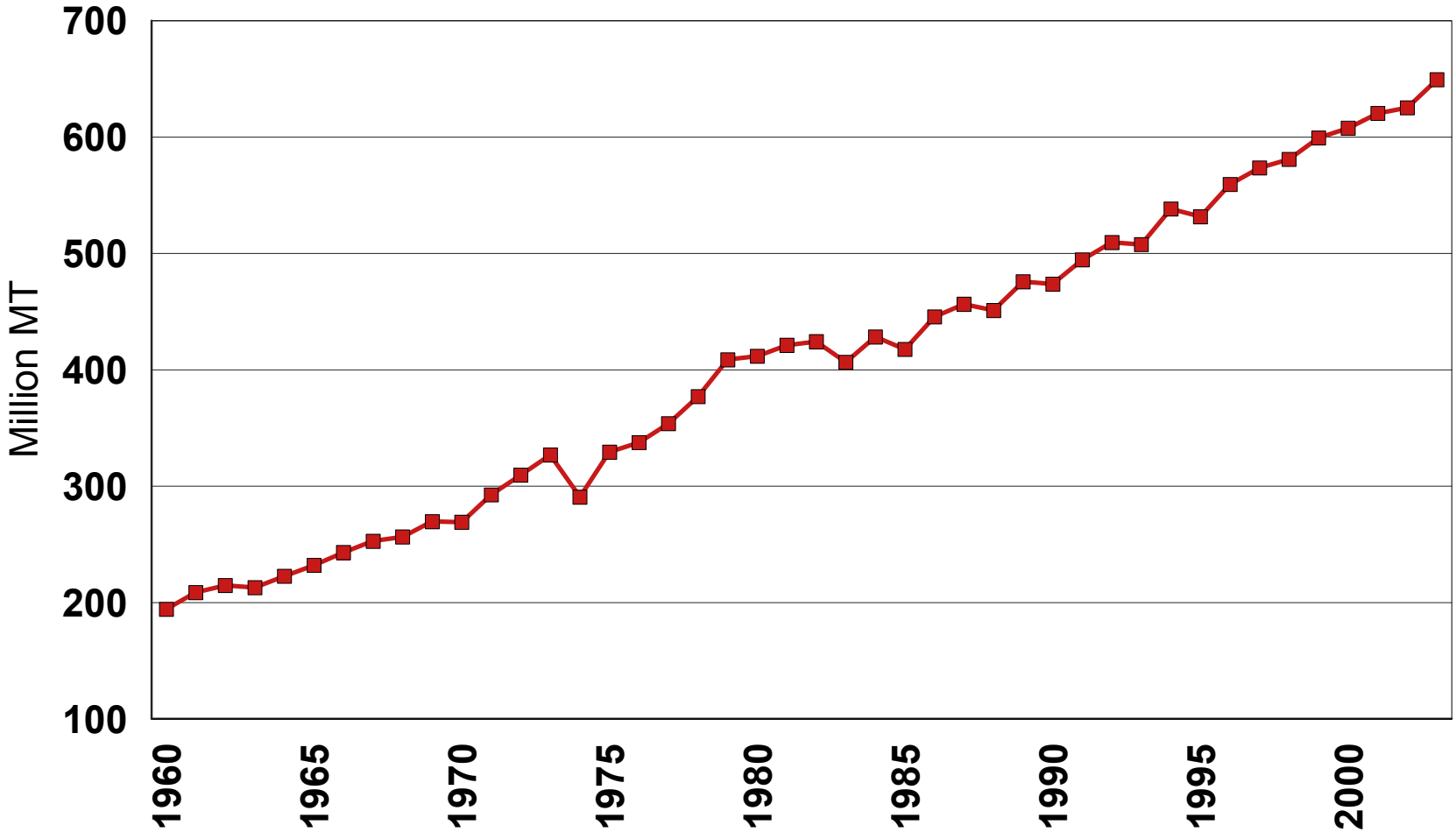
World Consumption



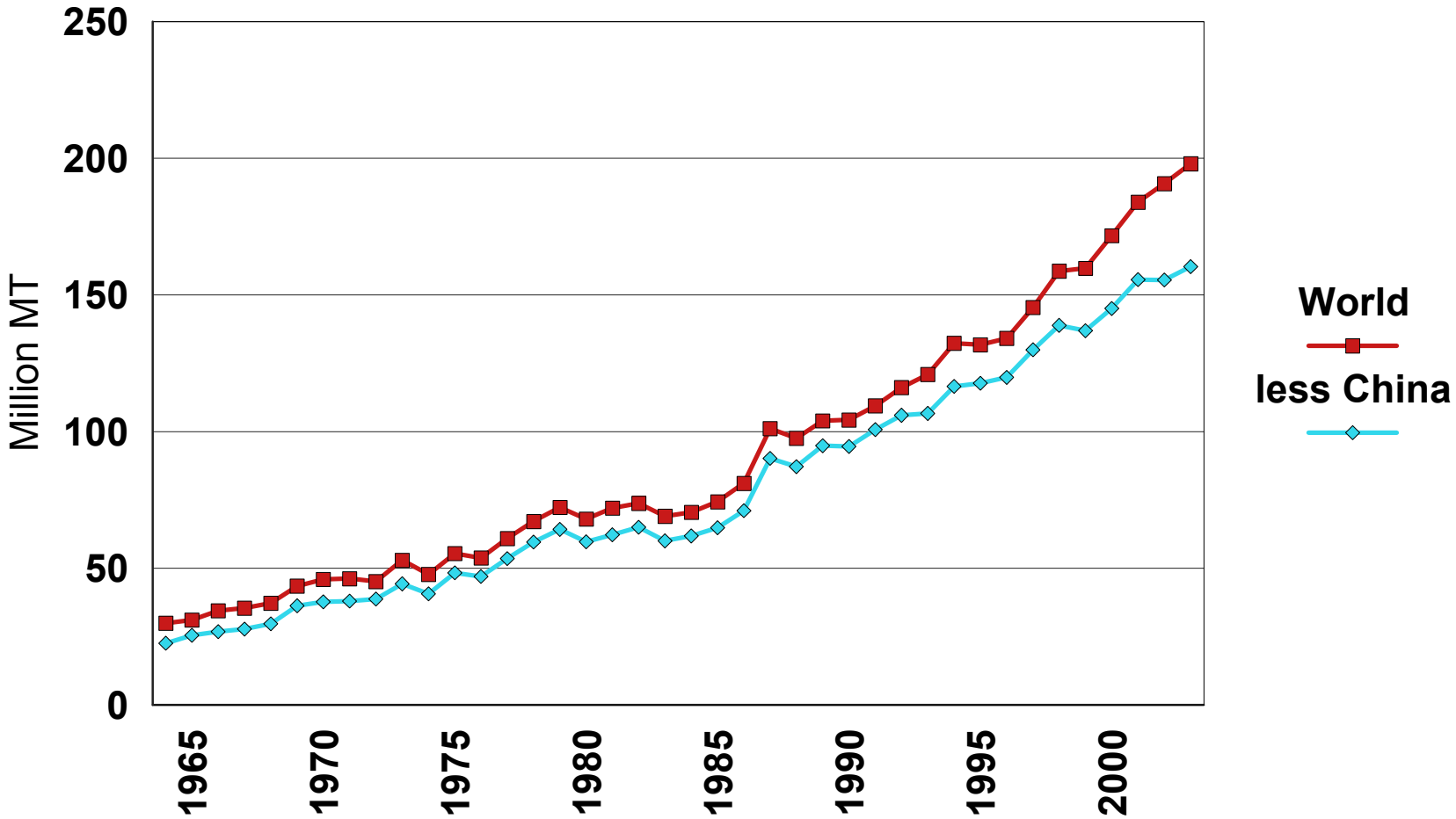
World Wheat Consumption



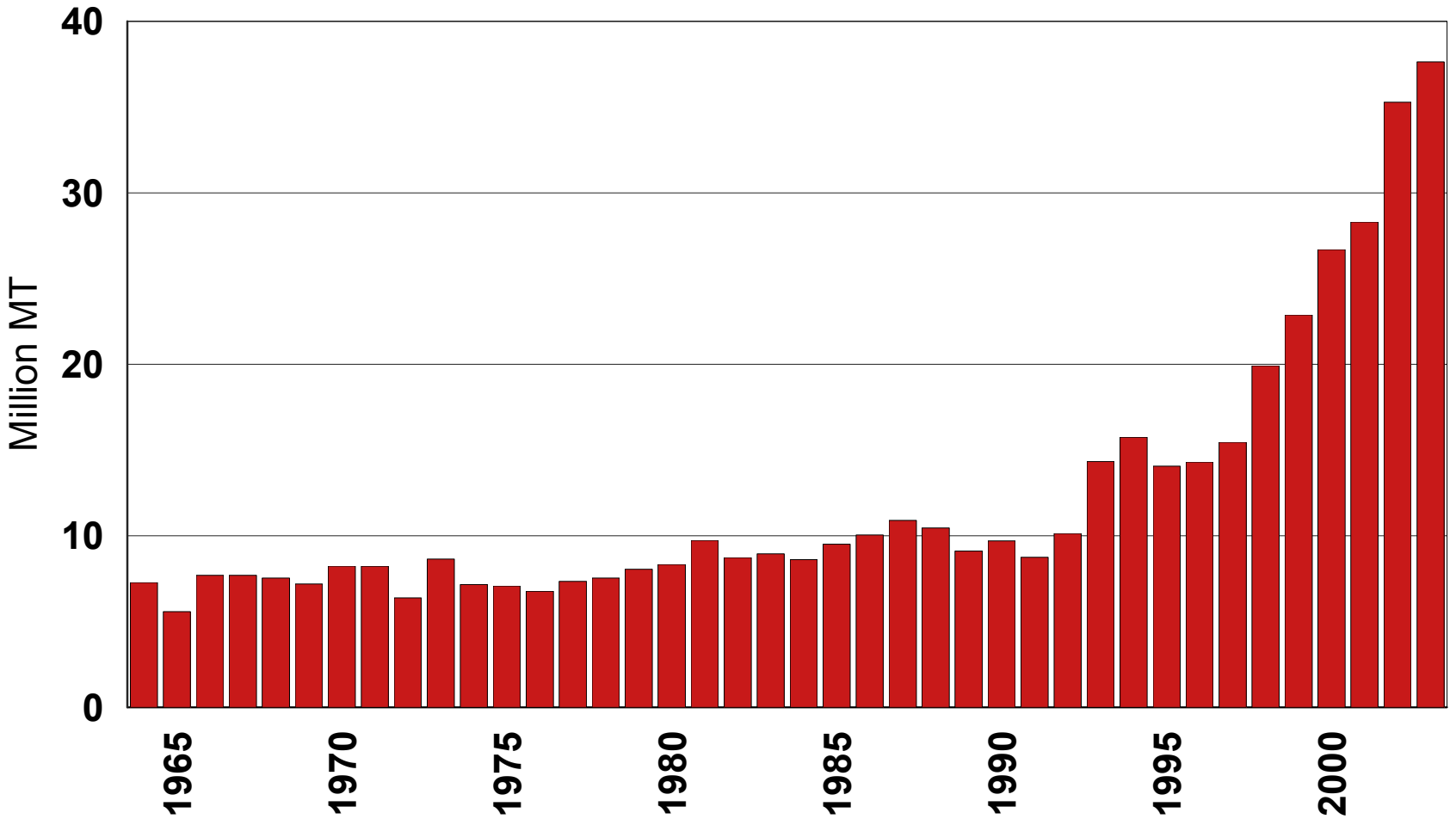
World Corn Consumption



World Soybean Consumption



China Soybean Consumption



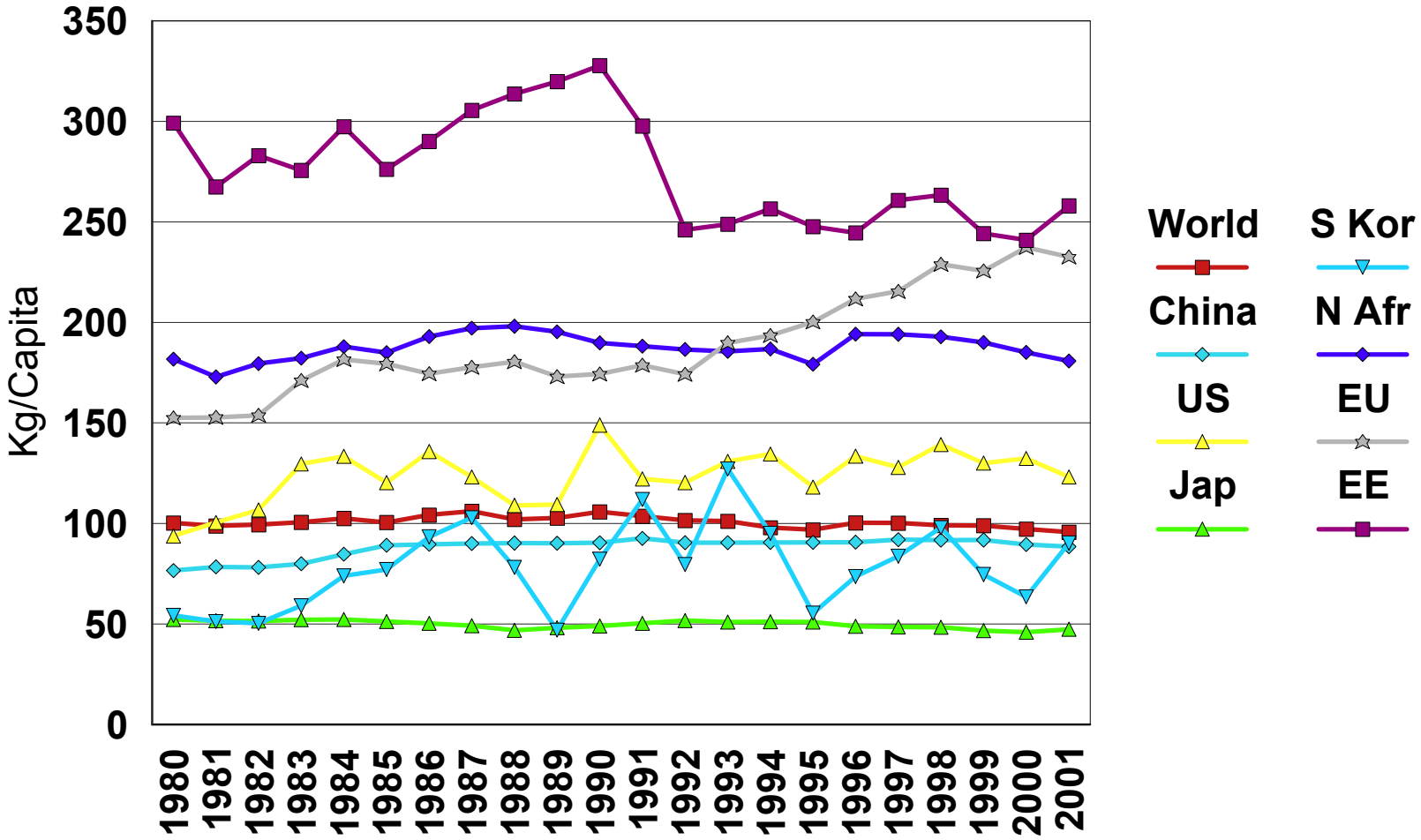
Production by Major Country/Region: % Change 1994-2003--over 10 years

	Wheat	Corn	Soybean
Argentina	0.19	0.10	1.72
Australia	1.81	1.07	2.09
Brazil	1.74	0.11	1.07
Canada	0.03	0.34	0.01
China; Peoples Republic of	-0.13	0.15	0.01
Japan	0.51	-0.50	1.83
Korea; Republic of	4.00	-0.21	-0.32
Mexico	-0.42	0.19	-0.76
United States	0.01	0.01	-0.04
Africa	0.38	0.22	0.08
Latin America	0.08	0.21	0.93
Europe	-0.05	0.04	0.00
S Asia	0.15	0.51	1.09
ME-FSU	0.07	1.22	-0.31
SE Asia	0.25	0.10	-0.13
World	0.05	0.10	0.38

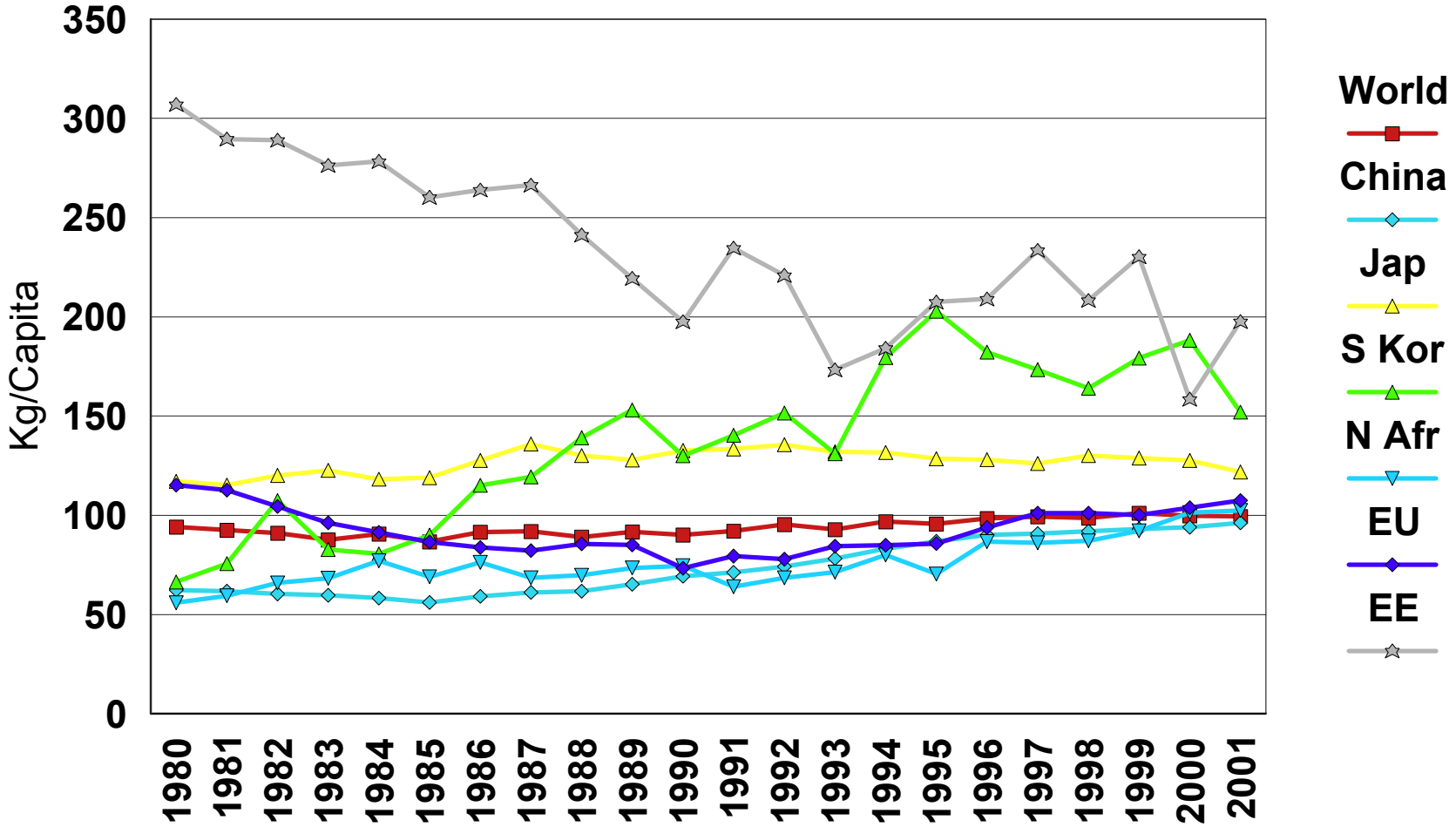
Consumption by Major Country/Region: % Change 1994-2003

	Wheat	corn	soybean
Argentina	0.22	-0.25	1.89
Australia	0.46	0.42	0.13
Brazil	0.25	0.07	0.57
Canada	0.01	0.48	0.26
China; Peoples Republic	-0.01	0.33	1.39
Japan	-0.05	0.03	0.06
Korea; Republic of	-0.25	0.21	0.05
Mexico	0.12	0.29	0.85
United States	-0.06	0.16	0.02
Africa	0.27	0.21	0.91
Latin America	0.11	0.29	0.93
Europe	0.14	0.14	0.06
S Asia	0.16	0.42	1.12
ME-FSU	-0.04	0.71	1.21
SE Asia	0.25	0.06	0.17
World	0.07	0.21	0.50

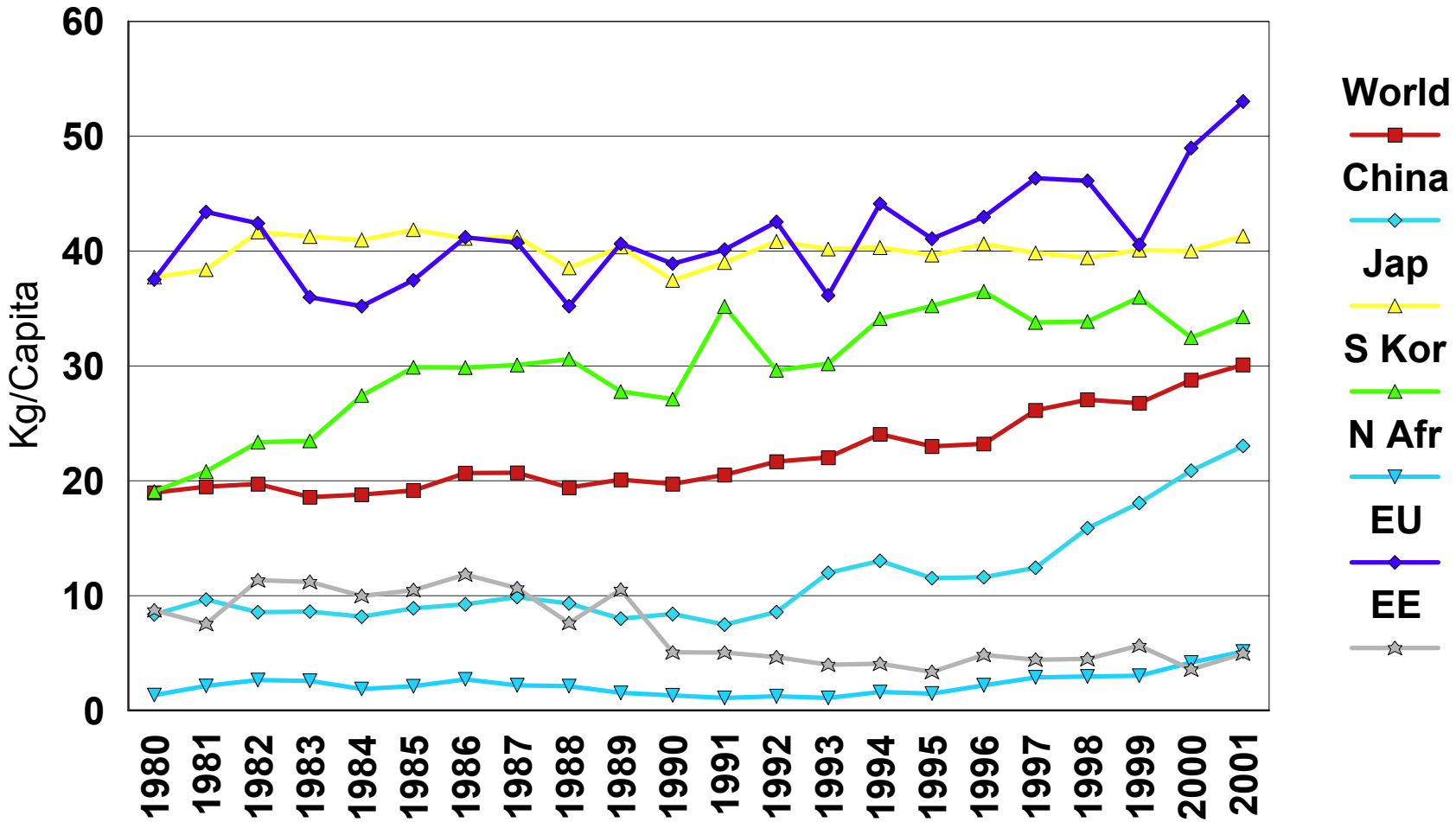
Per Capita Consumption: Wheat



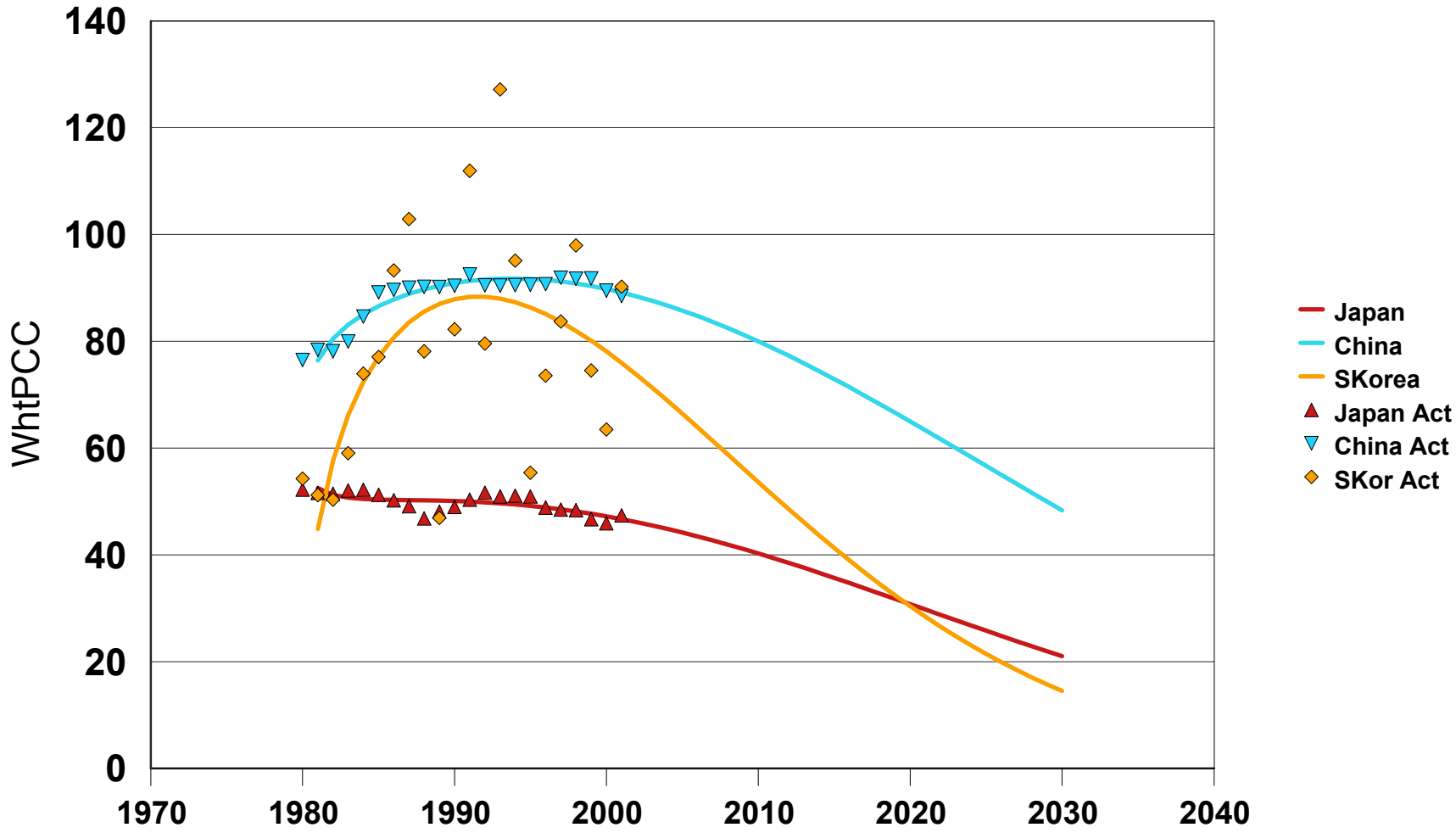
Per Capita Consumption: Corn



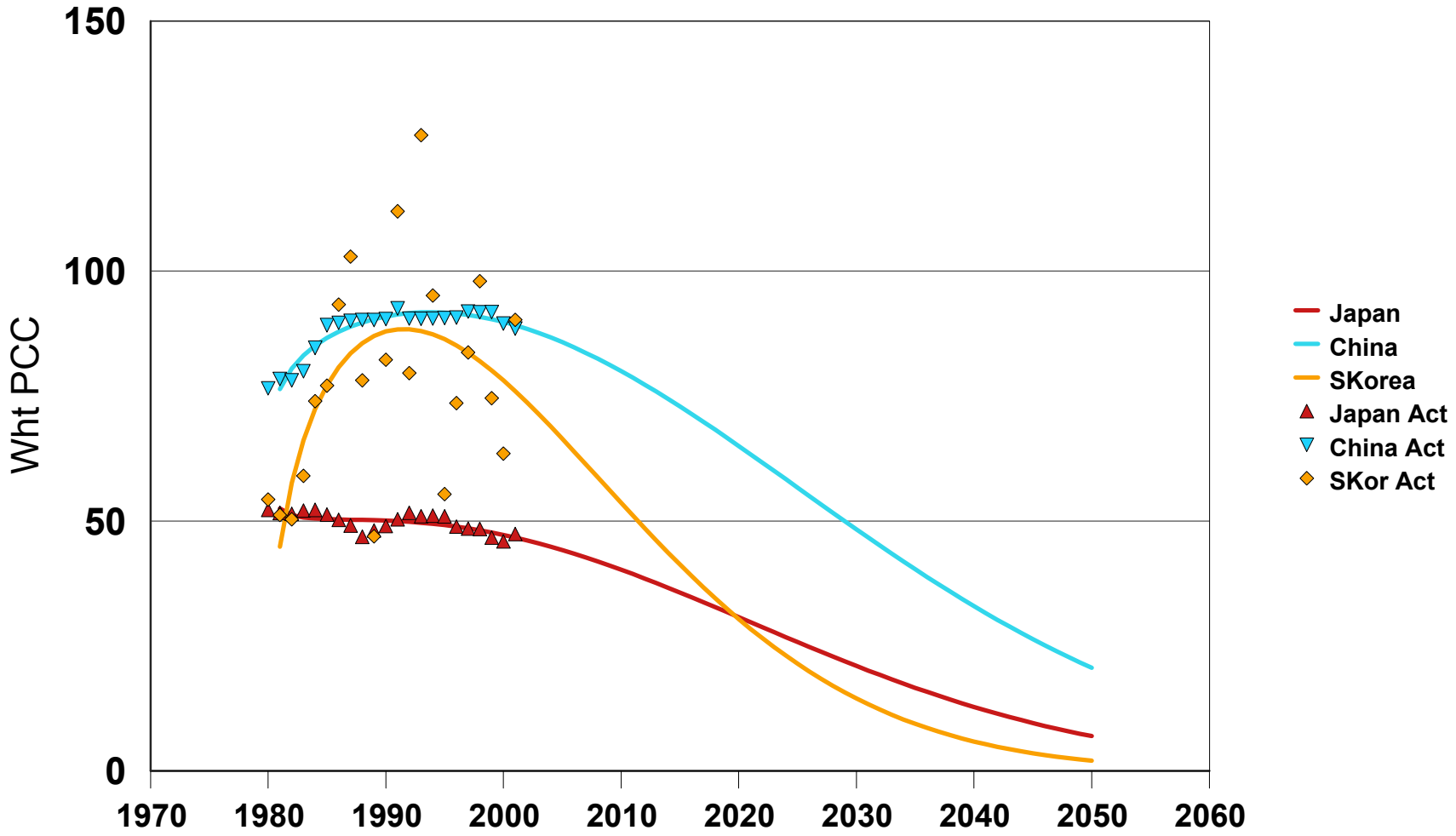
Per Capita Consumption: Soybeans



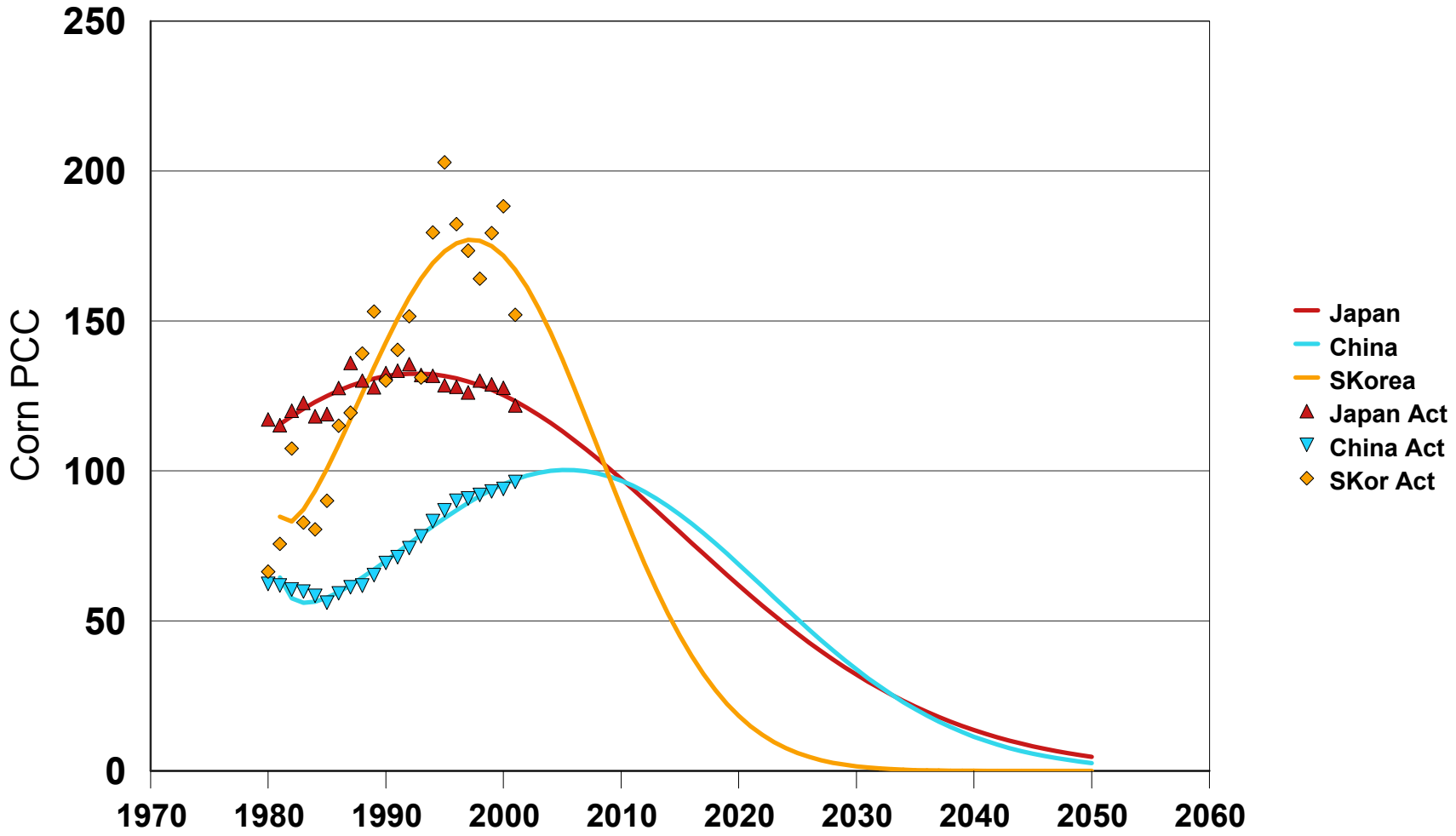
Wheat Per Capita Consumption Forecast to 2030 (Lifer)



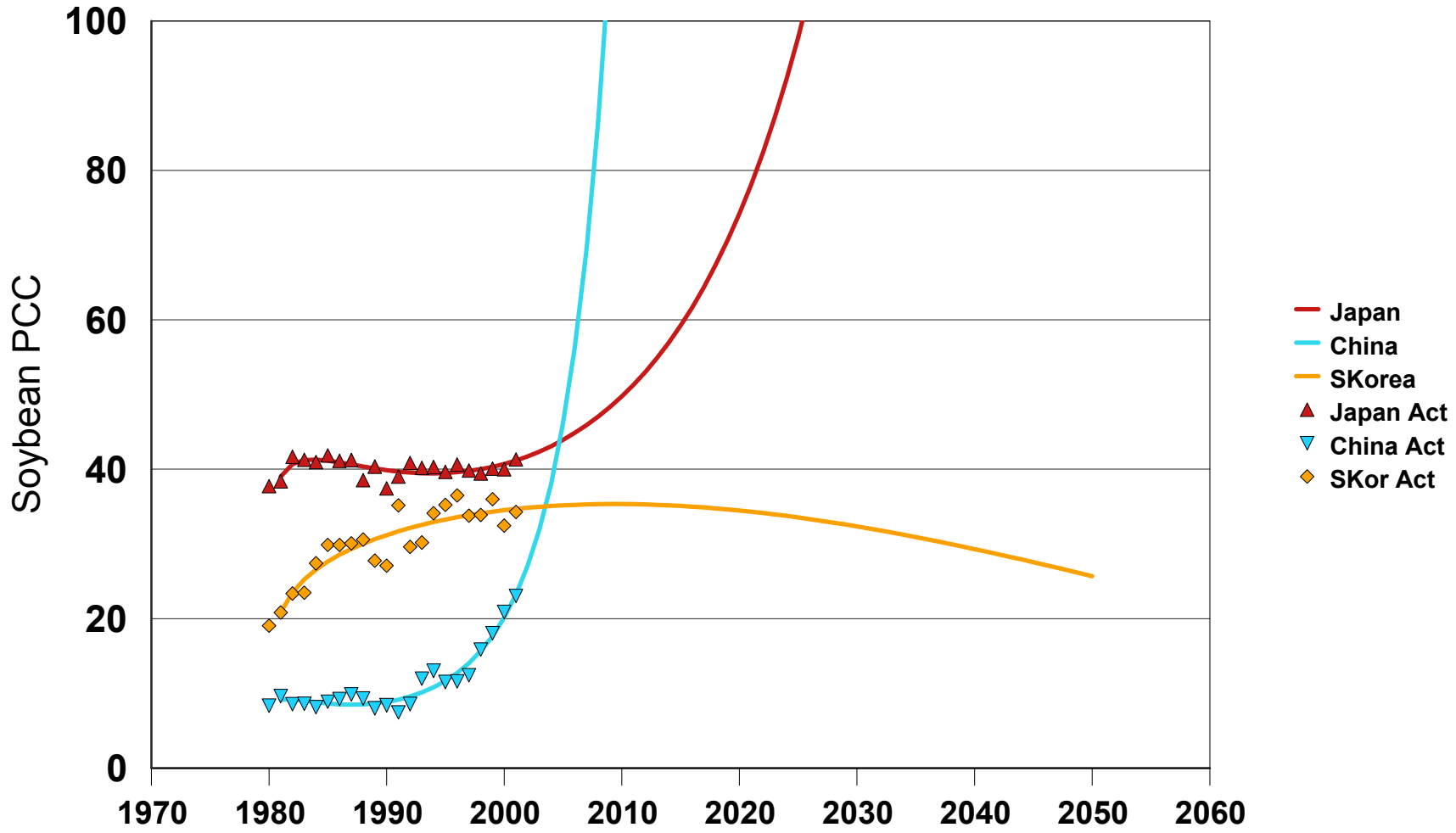
Wheat Per Capita Consumption Forecast to 2050 (Lifer)



Corn Per Capita Consumption Forecast to 2050 (Lifer)



Soybean Per Capita Consumption Forecast to 2050 (Lifer)



Consumption Functions

- Issue--in estimation
  - *Cons/popn=f(Y, tastes)+e*
  - Diminishing consumption rates in wheat
  - Explosive consumption in soybeans (in some countries)
  - Projection in a consistent way to capture maturing impact of Y and t on C and across countries

Ocean Freight to Asia and U.S. Corn Exports